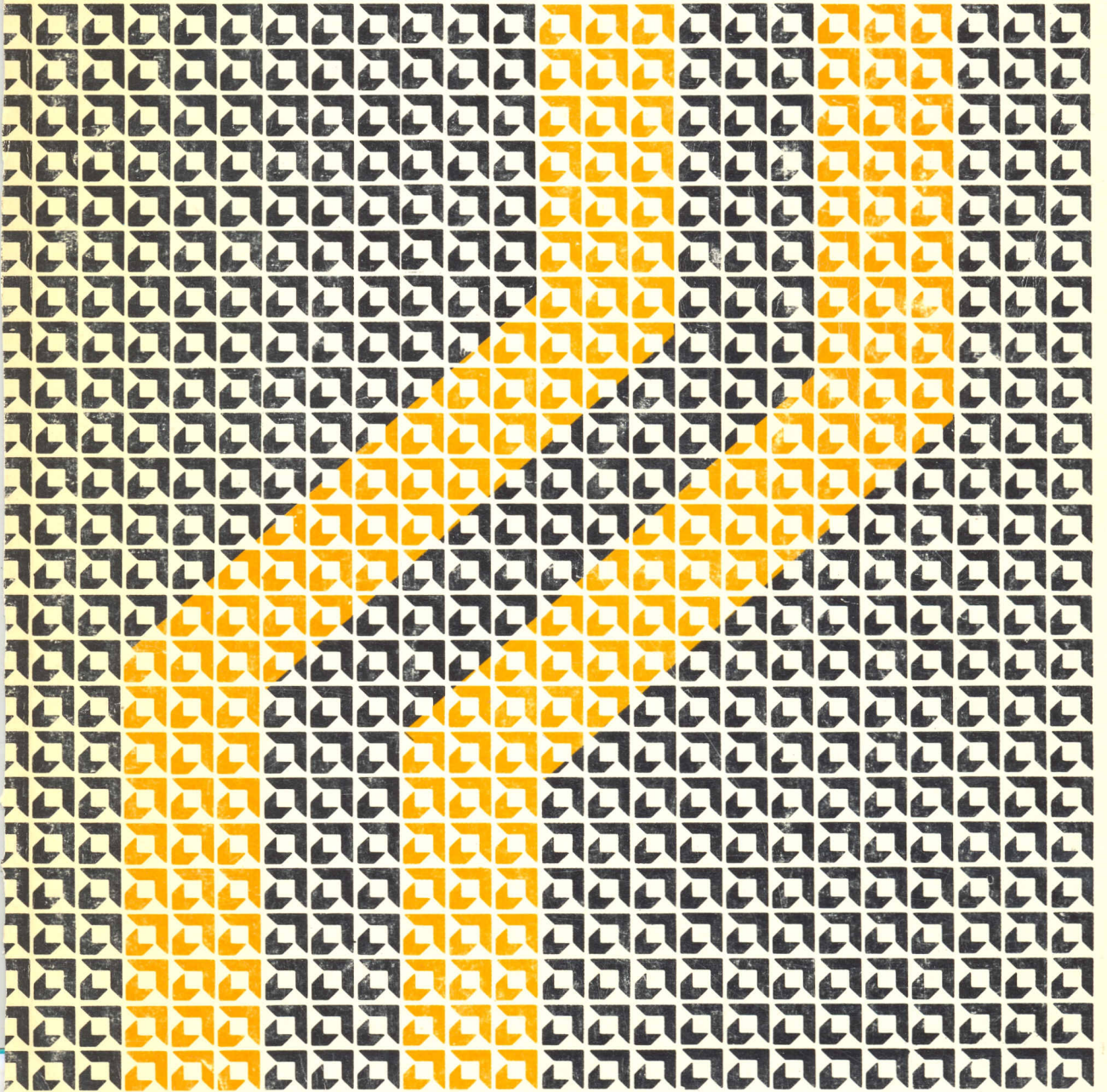




Advanced  
Micro  
Devices

The Am2900  
Family  
Data Book





# **Advanced Micro Devices**

## **The Am2900 Family Data Book With Related Support Circuits**

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AM-PUB003







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# Am2900 COMPONENTS CONTINUOUSLY BECOME FASTER AND FASTER

## MORE SPEED: NO MORE POWER

There's a good old tried and proven way to make faster IC's — burn more power. (That's the only real difference between "LS" and "S" devices). But that solution isn't satisfactory for LSI devices like the Am2900 family. Power is constrained to existing levels for reliability reasons.

Am2900 parts are always designed to obtain the maximum speed at a power level which is safe for the package types and operating environment of the part. To increase speeds, new technologies must be used to build faster components at no increase in power.

## NEW CIRCUIT DESIGN TECHNIQUES MAKE FASTER GATES

One way to make faster components is to use new circuit design techniques. The most obvious is internal ECL, which provides very fast gates at similar power levels to LS TTL. Other design techniques, such as low-level logic (with very small logic swings on-chip), can also provide higher speeds without introducing the time penalty of ECL to TTL conversion.

Finally, very low power gates used in non-critical speed paths make more power available for use in critical speed paths. As the 2900 family develops, all these technologies will be used within a single component to achieve the highest speeds without increasing power. Among the first products to take advantage of mixed-circuit technology will be the Am2903A.

## IMPROVED PROCESS CONTROL ALLOWS TIGHTER SPECS

Today's 2900 parts are carefully characterized over a wide range of voltages, temperatures, and process parameters be-

fore an AC specification is published. As manufacturing technology improves, the process is subject to smaller run-to-run variations, so that all of the product is closer to design nominal. This makes it possible to specify parameters more closely to typical without incurring large yield losses. The first product reflecting this is the Am2903.

## WHAT'S GOOD FOR THE GOOSE IS GOOD FOR THE GANDER

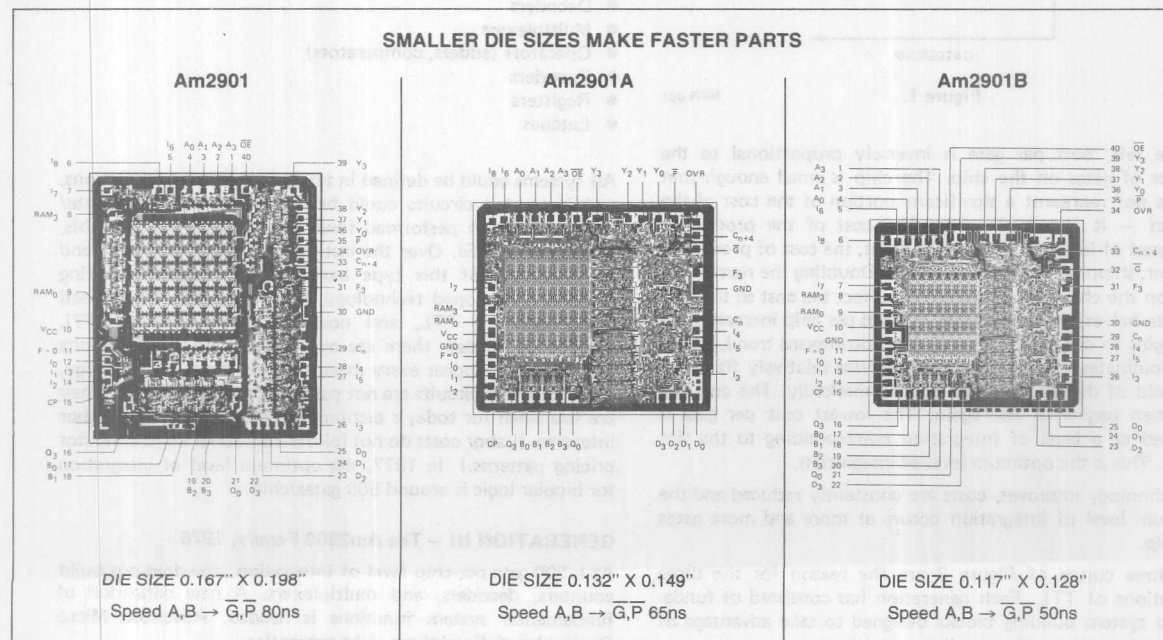
Many new tools in production technology are emerging, primarily spurred by the emphasis on high-speed MOS memories. The same tools, such as projection masking, also provide for smaller geometries in bipolar circuits. As MOS gets faster, so does bipolar. The Am2901B obtains its speed improvement over the Am2901A through these tools.

## DESIGN FOR THE FUTURE

Every Am2900 part will undergo an evolution as new technologies become practical for production. Every part type will continuously become faster. Within a few short years, 2900-based designs will compete favorably with Schottky MSI on a speed basis at a fraction of the component count.

Most existing 2900 designs can be offered in higher performance versions simply by substitution of the 2901B for the 2901A, the 2909A for the 2909, the 2903A for the 2903, and so forth. Your 2900 design won't run out of speed in a few years. Advanced Micro Devices' 2900 Family will serve tomorrow's needs as well as today's.

## SMALLER DIE SIZES MAKE FASTER PARTS



# INTRODUCTION

## THREE GENERATIONS OF TTL

Transistor-transistor logic has been the dominant technology for digital circuits since it was developed in the mid-1960's. It has proven itself to be manufacturable in high volume using an extremely reliable process technology. The processes used for TTL have evolved over the years, making components smaller, faster and less expensive. Relative to a TTL gate manufactured in 1966, a gate on a circuit manufactured today occupies 1/5 the area, consumes 1/10 the power, is twice as fast and costs less than 1/100 the price.

The circuits built using TTL technology have gone through two generations; the Am2900 Family represents the beginning of the third. Each generation consists of circuits which are fundamental building blocks of systems — circuits which can be interconnected in many different ways to build many different systems. Only by producing such universal circuits can manufacturing volumes be high enough to generate the rapid cost reductions characteristic of the integrated circuit industry.

The quality which distinguishes one generation from another is the level of integration used, and, because of the level of integration, the philosophy behind the circuit.

If one draws a curve plotting the cost of an individual gate against the number of gates on a chip, Figure 1 results.

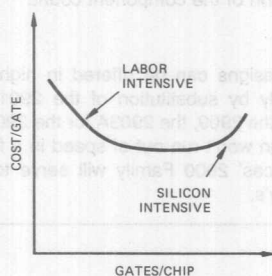


Figure 1.

MPR-001

At the left, cost per gate is inversely proportional to the number of gates on the chip. The chip is small enough that it does not represent a significant portion of the cost of the product — it is virtually free. The cost of the product is composed of labor in assembly and test, the cost of processing an order, shipping and fixed overhead. Doubling the number of gates on the chip doesn't materially affect the cost so the cost per gate halves. As the number of gates per chip increases, the die begins to cost more, reversing the downward trend. As die cost dominates, the cost per gate remains relatively flat until the yield of the die begins to decline markedly. The cost per gate then begins to rise again. The lowest cost per gate is achieved at a level of integration corresponding to the flat region. This is the optimum level of integration.

As technology improves, costs are constantly reduced and the optimum level of integration occurs at more and more gates per chip.

The three curves of Figure 2 are the reason for the three generations of TTL. Each generation has consisted of fundamental system building blocks designed to take advantage of the optimum level of integration at the time.

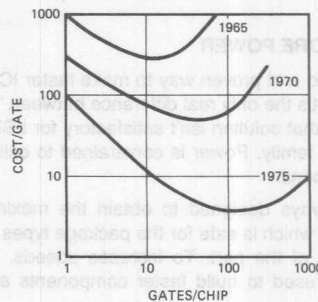


Figure 2.

MPR-002

### GENERATION I — SSI, 1965

In 1965, the optimum level of integration was three-to-six gates per chip. Users were delighted to buy such chips at \$10-20 each. The circuits were useful in many systems. They consisted of gates — the 7400, 7410, 7420 — and, pressing the state of the art, some flip-flops. They were fundamental building blocks.

### GENERATION II — MSI, 1970

Beginning around 1968, it became economical to put more gates on a chip and the industry was faced with a problem: How does one put 20 gates on a chip and build a universal building block? Clearly, one answer was to bring the inputs and outputs off chip as had been done before. But that was the wrong answer. The right answer was to redefine fundamental building blocks. The new building blocks fell into seven categories:

- Counters
- Decoders
- Multiplexers
- Operators (adders, comparators)
- Encoders
- Registers
- Latches

All systems could be defined in terms of these seven functions, and integrated circuits could be defined at the 20-50 gate/chip level which performed these functions efficiently. This, of course, is MSI. Over the last six or seven years, more and more circuits of this type have been introduced, utilizing standard gold-doped technology, low-power TTL, high-speed TTL, Schottky TTL, and now low-power Schottky TTL technology. Today, there are over 250 different MSI circuits and new ones appear every month. But in today's technology, many of these circuits are not particularly cost effective. They are too small for today's technology and their costs are labor intensive. (Labor costs do not follow traditional semiconductor pricing patterns.) In 1977, the optimum level of integration for bipolar logic is around 500 gates/chip.

### GENERATION III — The Am2900 Family, 1976

At a 500-gate-per-chip level of integration, one does not build counters, decoders, and multiplexers. A new definition of fundamental system functions is needed. Advanced Micro Devices has defined these eight categories:



- Data Manipulation
- Microprogram Control
- Macroprogram Control
- Priority Interrupt
- Direct Memory Access
- I/O Control
- Memory Control
- Front Panel Control

The Am2900 Family consists of circuits designed to perform those functions efficiently. They are fundamental system building blocks; they contain hundreds of gates per chip; they are fast — utilizing Low-Power Schottky TTL technology; they are expandable; they are flexible — useful in emulation; and they are driven under microprogram control.

### THE Am2900 FAMILY

The Am2900 Family consists of a series of LSI building blocks designed for use in microprogrammed computers and controllers. Each device is designed to be expandable and sufficiently flexible to be suitable for emulation of many existing machines. It is the wide variety of machine architectures possible with the Am2900 Family which sets it apart from the fixed-instruction microprocessors such as the Am9080A.

While an Am9080A can be used to build a microcomputer with only four or five packages, an Am2900 design will require 30 or 40 or more. The Am9080A design will, therefore, almost always be cheaper. But the Am9080A, or any other fixed-instruction processor, can execute only one instruction set, so it is not really suitable for emulation of another machine.

Moreover, a fixed-instruction processor operates only on words of a single length, usually eight bits. An Am2900 design, on the other hand, can be constructed for any word length which is a multiple of four bits.

Many applications require specialized operations to be performed at relatively high speed. Such functions as multiply and divide and special graphic control operations, can be done in microcode 10-100 times faster than in fixed-instruction MOS processors.

### MICROPROGRAMMED ARCHITECTURE

Most small processors today are being designed using a technique called microprogramming. In microprogrammed systems, a large portion of the system's control is performed by a read only memory (usually PROM) rather than large arrays of gates and flip-flops. This technique frequently reduces the package count in the controller and provides a highly ordered structure in the controller, not present when random logic is used. Moreover, microprogramming makes changes in the machines' instruction set very simple to perform — reducing the post-production engineering costs for the system substantially.

The Am2900 Family of Bipolar LSI devices has been designed for use in microprogrammed systems. Each device performs a basic system function and is driven by a set of control lines from a microinstruction.

Figure 3 illustrates a typical system architecture. There are two "sides" to the system. At the left is the control circuitry and on the right is the data manipulation circuitry. The block labeled "2901 array" consists of the ALU, scratchpad registers, data steering logic (all internal to the Am2901's), plus left/

right shift control and carry lookahead circuit. Data is processed by moving it from main memory (not shown) into the 2901 registers, performing the required operations on it and returning the result to main memory. Memory addresses may also be generated in the 2901's and sent out to the memory address register (MAR). The four status bits from the 2901's ALU are captured in the status register after each operation.

The logic on the left side is the control section of the computer. This is where the Am2909, 2910, or 2911 is used. The entire system is controlled by a memory, usually PROM, which contains long words called microinstructions. Each microinstruction contains bits to control each of the data manipulation elements in the system. There are, for example, nine bits for the 2901 instruction lines, eight bits for the A and B register addresses, two or three bits to control the shifting multiplexers at the ends of the 2901 array (Figure 19 on 2901 data sheet), and bits to control the register enables on the MAR, instruction register, and various bus transceivers. When the bits in a microinstruction are applied to all the data elements and everything is clocked, then one small operation (such as a data transfer or a register-to-register add) will occur.

A "machine instruction" (such as a minicomputer instruction or a 9080A instruction) is performed by executing several microinstructions in sequence. Each microinstruction therefore contains not only bits to control the data hardware, but also bits to define the location in PROM of the next microinstruction to be executed. The fields are labeled in Figure 3 as I, CC, and BA. The I field controls the sequencer. It indicates where the next address is located — the  $\mu$ PC, the stack, or the direct inputs — and whether the stack is to be pushed or popped.

The CC field contains bits indicating the conditions under which the I field applies. These are compared with the condition codes in the status register and may cause modification to the I field. The comparing and modification occurs in the block labeled "control logic". Frequently this is a PROM or PLA. In the case of the Am2910, it is built into the chip. The BA field is a branch address or the address of a subroutine.

### PIPELINING

The address for the microinstructions is generated by the sequencer, starting from a clock edge. The address goes from the sequencer to the ROM and, an access time later, the microinstruction is at the ROM outputs.

A pipeline register is a register placed on the output of the microprogram memory to essentially split the system in two. The pipeline register contains the microinstruction currently being executed ①. (Refer to the circled numbers in Figure 3.) The data manipulation control bits go out to the system elements and a portion of the microinstruction is returned to the sequencer ② to determine the address of the next microinstruction to be executed. That address ③ is sent to the ROM and the next microinstruction ④ sits at the input of the pipeline register. So while the 2901's are executing one instruction, the next instruction is being fetched from ROM. Note that there is no sequential logic in the sequencer between the select lines and the output. This is important because the loop ① to ② to ③ to ④ must occur during a single clock cycle. During the same time, the loop from ① to ⑤ must occur in the 2901's. These two paths are roughly the same (around 200ns worst case for a 16-bit system). The presence of the pipeline register allows the microinstruction fetch to occur in parallel with the data operation rather than serially, allowing the clock frequency to be doubled.

## Introduction

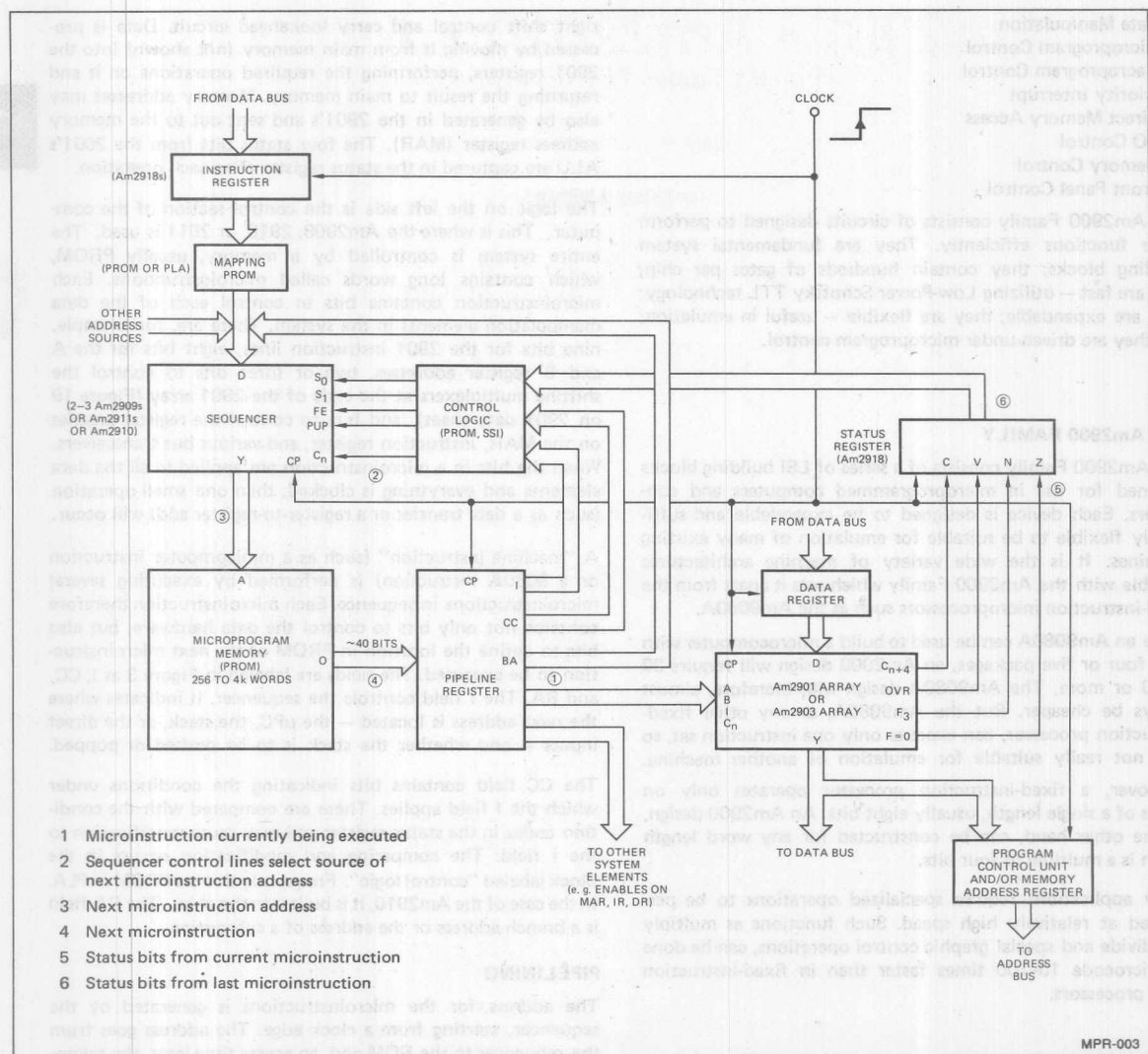


Figure 3.

The system shown in Figure 3 works as follows. A sequence of microinstructions in the PROM is executed to fetch an instruction from main memory. This requires that the program counter, often in a 2901 working register, be sent to the memory address register and incremented. The data returned from memory is loaded into the instruction register. The contents of the instruction register is passed through a PROM or PLA to generate the address of the first microinstruction which must be executed to perform the required function. A branch to this address occurs through the sequencer. Several microinstructions may be executed to fetch data from memory, perform ALU operations, test for overflow, and so forth. Then a branch will be made back to the instruction fetch cycle. At this point, there may be branches to other sections of micro-

code. For example, the machine might test for an interrupt here and obtain an interrupt service routine address from another mapping ROM rather than start on the next machine instruction. There are obviously many possibilities. Throughout this data book, in application notes, and within data sheets, some suggested techniques will be found.

Additional application notes are in preparation and are planned for publication. Advanced Micro Devices' Applications' staff is available to answer questions and provide technical assistance as well. They may be reached by calling (408) 732-2400, or, outside California (800) 538-8450. Ask for Am2900 Family Applications.

# Am2901 • Am2901A • Am2901B

## Four-Bit Bipolar Microprocessor Slice

### DISTINCTIVE CHARACTERISTICS

- Two-address architecture – Independent simultaneous access to two working registers saves machine cycles.
- Eight-function ALU – Performs addition, two subtraction operations, and five logic functions on two source operands.
- Flexible data source selection – ALU data is selected from five source ports for a total of 203 source operand pairs for every ALU function.
- Left/right shift independent of ALU – Add and shift operations take only one cycle.
- Four status flags – Carry, overflow, zero, and negative.
- Expandable – Connect any number of Am2901's together for longer word lengths.
- Microprogrammable – Three groups of three bits each for source operand, ALU function, and destination control.
- Fast – Am2901B is up to 27% faster than Am2901A, up to 50% faster than Am2901. The Am2901B meets or exceeds all of the specifications for the Am2901 and Am2901A.

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For applications information see the last part of this data sheet and chapters III and IV of "Build a Microcomputer", AMD's application note series on the Am2900 Family.

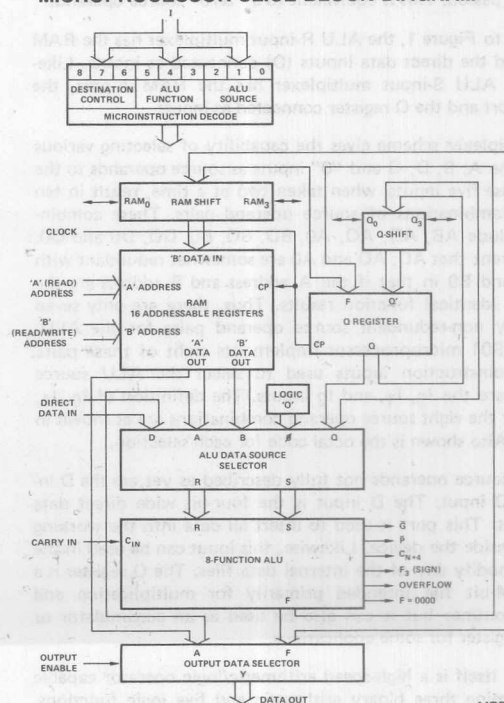
### GENERAL DESCRIPTION

The four-bit bipolar microprocessor slice is designed as a high-speed cascadable element intended for use in CPU's, peripheral controllers, programmable microprocessors and numerous other applications. The microinstruction flexibility of the Am2901 will allow efficient emulation of almost any digital computing machine.

The device, as shown in the block diagram below, consists of a 16-word by 4-bit two-port RAM, a high-speed ALU, and the associated shifting, decoding and multiplexing circuitry. The nine-bit microinstruction word is organized into three groups of three bits each and selects the ALU source operands, the ALU function, and the ALU destination register. The microprocessor is cascadable with full look-ahead or with ripple carry, has three-state outputs, and provides various status flag outputs from the ALU. Advanced low-power Schottky processing is used to fabricate this 40-lead LSI chip.

The Am2901B is a plug-in replacement for the Am2901 or Am2901A, but is 25% faster than the Am2901A and 50% faster than the Am2901.

### MICROPROCESSOR SLICE BLOCK DIAGRAM



MPR-004



## ARCHITECTURE

A detailed block diagram of the bipolar microprogrammable microprocessor structure is shown in Figure 1. The circuit is a four-bit slice cascable to any number of bits. Therefore, all data paths within the circuit are four bits wide. The two key elements in the Figure 1 block diagram are the 16-word by 4-bit 2-port RAM and the high-speed ALU.

Data in any of the 16 words of the Random Access Memory (RAM) can be read from the A-port of the RAM as controlled by the 4-bit A address field input. Likewise, data in any of the 16 words of the RAM as defined by the B address field input can be simultaneously read from the B-port of the RAM. The same code can be applied to the A select field and B select field in which case the identical file data will appear at both the RAM A-port and B-port outputs simultaneously.

When enabled by the RAM write enable (RAM EN), new data is always written into the file (word) defined by the B address field of the RAM. The RAM data input field is driven by a 3-input multiplexer. This configuration is used to shift the ALU output data (F) if desired. This three-input multiplexer scheme allows the data to be shifted up one bit position, shifted down one bit position, or not shifted in either direction.

The RAM A-port data outputs and RAM B-port data outputs drive separate 4-bit latches. These latches hold the RAM data while the clock input is LOW. This eliminates any possible race conditions that could occur while new data is being written into the RAM.

The high-speed Arithmetic Logic Unit (ALU) can perform three binary arithmetic and five logic operations on the two 4-bit input words R and S. The R input field is driven from a 2-input multiplexer, while the S input field is driven from a 3-input multiplexer. Both multiplexers also have an inhibit capability; that is, no data is passed. This is equivalent to a "zero" source operand.

Referring to Figure 1, the ALU R-input multiplexer has the RAM A-port and the direct data inputs (D) connected as inputs. Likewise, the ALU S-input multiplexer has the RAM A-port, the RAM B-port and the Q register connected as inputs.

This multiplexer scheme gives the capability of selecting various pairs of the A, B, D, Q and "0" inputs as source operands to the ALU. These five inputs, when taken two at a time, result in ten possible combinations of source operand pairs. These combinations include AB, AD, AQ, A0, BD, BQ, B0, DQ, D0 and Q0. It is apparent that AD, AQ and A0 are somewhat redundant with BD, BQ and B0 in that if the A address and B address are the same, the identical function results. Thus, there are only seven completely non-redundant source operand pairs for the ALU. The Am2901 microprocessor implements eight of these pairs. The microinstruction inputs used to select the ALU source operands are the I<sub>0</sub>, I<sub>1</sub>, and I<sub>2</sub> inputs. The definition of I<sub>0</sub>, I<sub>1</sub>, and I<sub>2</sub> for the eight source operand combinations are as shown in Figure 2. Also shown is the octal code for each selection.

The two source operands not fully described as yet are the D input and Q input. The D input is the four-bit wide direct data field input. This port is used to insert all data into the working registers inside the device. Likewise, this input can be used in the ALU to modify any of the internal data files. The Q register is a separate 4-bit file intended primarily for multiplication and division routines but it can also be used as an accumulator or holding register for some applications.

The ALU itself is a high-speed arithmetic/logic operator capable of performing three binary arithmetic and five logic functions. The I<sub>3</sub>, I<sub>4</sub>, and I<sub>5</sub> microinstruction inputs are used to select the

ALU function. The definition of these inputs is shown in Figure 3. The octal code is also shown for reference. The normal technique for cascading the ALU of several devices is in a look-ahead carry mode. Carry generate,  $\bar{G}$ , and carry propagate,  $\bar{P}$ , are outputs of the device for use with a carry-look-ahead-generator such as the Am2902. A carry-out, C<sub>n+4</sub>, is also generated and is available as an output for use as the carry flag in a status register. Both carry-in (C<sub>n</sub>) and carry-out (C<sub>n+4</sub>) are active HIGH.

The ALU has three other status-oriented outputs. These are F<sub>3</sub>, F = 0, and overflow (OVR). The F<sub>3</sub> output is the most significant (sign) bit of the ALU and can be used to determine positive or negative results without enabling the three-state data outputs. F<sub>3</sub> is non-inverted with respect to the sign bit output Y<sub>3</sub>. The F = 0 output is used for zero detect. It is an open-collector output and can be wire OR'ed between microprocessor slices. F = 0 is HIGH when all F outputs are LOW. The overflow output (OVR) is used to flag arithmetic operations that exceed the available two's complement number range. The overflow output (OVR) is HIGH when overflow exists. That is, when C<sub>n+3</sub> and C<sub>n+4</sub> are not the same polarity.

The ALU data output is routed to several destinations. It can be a data output of the device and it can also be stored in the RAM or the Q register. Eight possible combinations of ALU destination functions are available as defined by the I<sub>6</sub>, I<sub>7</sub>, and I<sub>8</sub> microinstruction inputs. These combinations are shown in Figure 4.

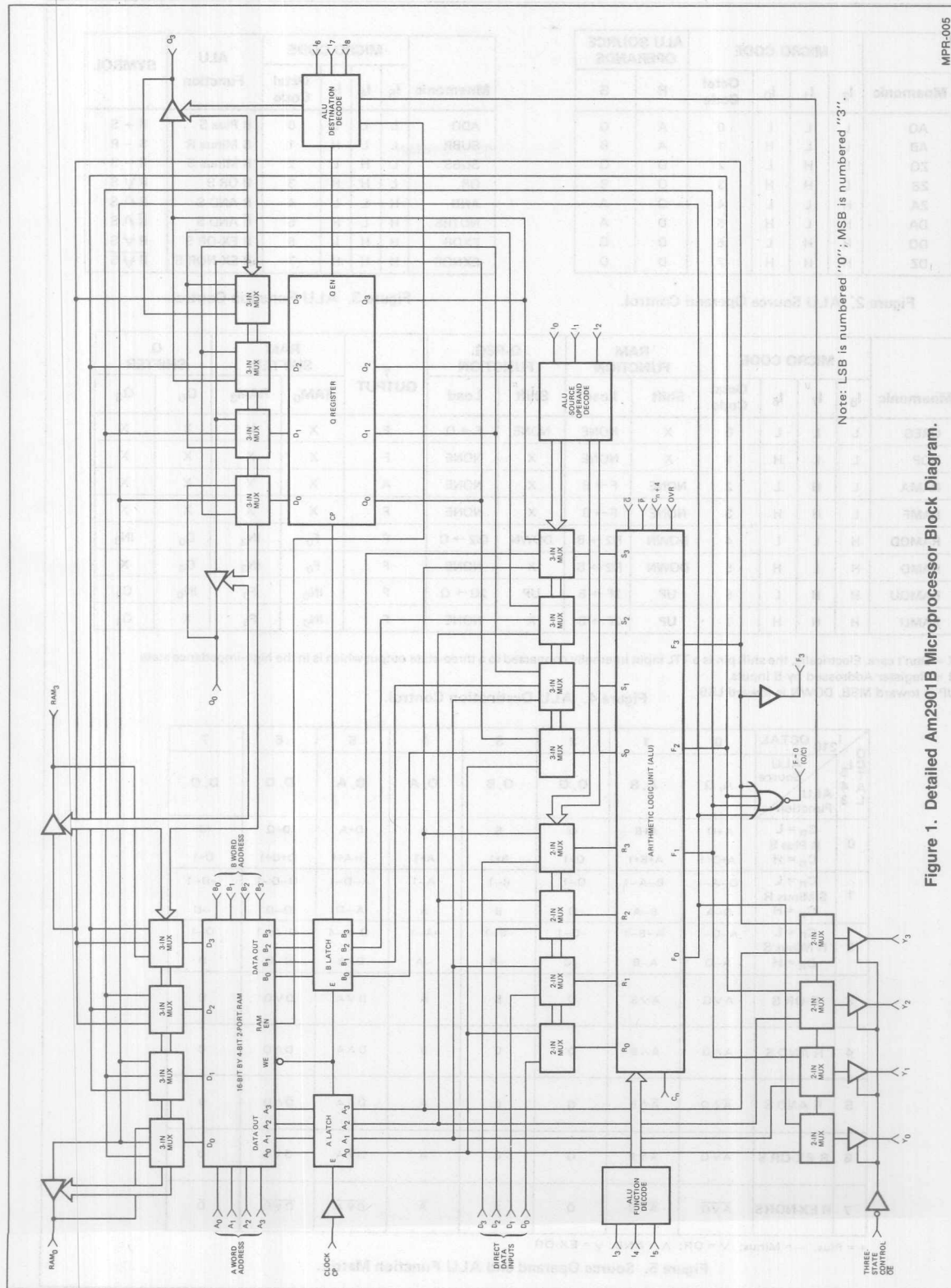
The four-bit data output field (Y) features three-state outputs and can be directly bus organized. An output control (OE) is used to enable the three-state outputs. When OE is HIGH, the Y outputs are in the high-impedance state.

A two-input multiplexer is also used at the data output such that either the A-port of the RAM or the ALU outputs (F) are selected at the device Y outputs. This selection is controlled by the I<sub>6</sub>, I<sub>7</sub>, and I<sub>8</sub> microinstruction inputs. Refer to Figure 4 for the selected output for each microinstruction code combination.

As was discussed previously, the RAM inputs are driven from a three-input multiplexer. This allows the ALU outputs to be entered non-shifted, shifted up one position (X2) or shifted down one position ( $\div 2$ ). The shifter has two ports; one is labeled RAM<sub>0</sub> and the other is labeled RAM<sub>3</sub>. Both of these ports consist of a buffer-driver with a three-state output and an input to the multiplexer. Thus, in the shift up mode, the RAM<sub>3</sub> buffer is enabled and the RAM<sub>0</sub> multiplexer input is enabled. Likewise, in the shift down mode, the RAM<sub>0</sub> buffer and RAM<sub>3</sub> input are enabled. In the no-shift mode, both buffers are in the high-impedance state and the multiplexer inputs are not selected. This shifter is controlled from the I<sub>6</sub>, I<sub>7</sub> and I<sub>8</sub> microinstruction inputs as defined in Figure 4.

Similarly, the Q register is driven from a 3-input multiplexer. In the no-shift mode, the multiplexer enters the ALU data into the Q register. In either the shift-up or shift-down mode, the multiplexer selects the Q register data appropriately shifted up or down. The Q shifter also has two ports; one is labeled Q<sub>0</sub> and the other is Q<sub>3</sub>. The operation of these two ports is similar to the RAM shifter and is also controlled from I<sub>6</sub>, I<sub>7</sub>, and I<sub>8</sub> as shown in Figure 4.

The clock input to the Am2901 controls the RAM, the Q register, and the A and B data latches. When enabled, data is clocked into the Q register on the LOW-to-HIGH transition of the clock. When the clock input is HIGH, the A and B latches are open and will pass whatever data is present at the RAM outputs. When the clock input is LOW, the latches are closed and will retain the last data entered. If the RAM-EN is enabled, new data will be written into the RAM file (word) defined by the B address field when the clock input is LOW.



**Figure 1. Detailed Am2901B Microprocessor Block Diagram.**

| Mnemonic | MICRO CODE     |                |                |            | ALU SOURCE OPERANDS |   |
|----------|----------------|----------------|----------------|------------|---------------------|---|
|          | I <sub>2</sub> | I <sub>1</sub> | I <sub>0</sub> | Octal Code | R                   | S |
| AQ       | L              | L              | L              | 0          | A                   | Q |
| AB       | L              | L              | H              | 1          | A                   | B |
| ZQ       | L              | H              | L              | 2          | O                   | Q |
| ZB       | L              | H              | H              | 3          | O                   | B |
| ZA       | H              | L              | L              | 4          | O                   | A |
| DA       | H              | L              | H              | 5          | D                   | A |
| DQ       | H              | H              | L              | 6          | D                   | Q |
| DZ       | H              | H              | H              | 7          | D                   | O |

Figure 2. ALU Source Operand Control.

| Mnemonic | MICRO CODE     |                |                |            | ALU Function    | SYMBOL                  |
|----------|----------------|----------------|----------------|------------|-----------------|-------------------------|
|          | I <sub>5</sub> | I <sub>4</sub> | I <sub>3</sub> | Octal Code |                 |                         |
| ADD      | L              | L              | L              | 0          | R Plus S        | R + S                   |
| SUBR     | L              | L              | H              | 1          | S Minus R       | S - R                   |
| SUBS     | L              | H              | L              | 2          | R Minus S       | R - S                   |
| OR       | L              | H              | H              | 3          | R OR S          | R ∨ S                   |
| AND      | H              | L              | L              | 4          | R AND S         | R ∧ S                   |
| NOTRS    | H              | L              | H              | 5          | $\bar{R}$ AND S | $\bar{R} \wedge S$      |
| EXOR     | H              | H              | L              | 6          | R EX-OR S       | R ⊕ S                   |
| EXNOR    | H              | H              | H              | 7          | R EX-NOR S      | $\overline{R \oplus S}$ |

Figure 3. ALU Function Control.

| Mnemonic | MICRO CODE     |                |                |            | RAM FUNCTION |         | Q-REG. FUNCTION |         | Y OUTPUT | RAM SHIFTER      |                  | Q SHIFTER       |                 |
|----------|----------------|----------------|----------------|------------|--------------|---------|-----------------|---------|----------|------------------|------------------|-----------------|-----------------|
|          | I <sub>8</sub> | I <sub>7</sub> | I <sub>6</sub> | Octal Code | Shift        | Load    | Shift           | Load    |          | RAM <sub>0</sub> | RAM <sub>3</sub> | Q <sub>0</sub>  | Q <sub>3</sub>  |
| QREG     | L              | L              | L              | 0          | X            | NONE    | NONE            | F → Q   | F        | X                | X                | X               | X               |
| NOP      | L              | L              | H              | 1          | X            | NONE    | X               | NONE    | F        | X                | X                | X               | X               |
| RAMA     | L              | H              | L              | 2          | NONE         | F → B   | X               | NONE    | A        | X                | X                | X               | X               |
| RAMF     | L              | H              | H              | 3          | NONE         | F → B   | X               | NONE    | F        | X                | X                | X               | X               |
| RAMQD    | H              | L              | L              | 4          | DOWN         | F/2 → B | DOWN            | Q/2 → Q | F        | F <sub>0</sub>   | IN <sub>3</sub>  | Q <sub>0</sub>  | IN <sub>3</sub> |
| RAMD     | H              | L              | H              | 5          | DOWN         | F/2 → B | X               | NONE    | F        | F <sub>0</sub>   | IN <sub>3</sub>  | Q <sub>0</sub>  | X               |
| RAMQU    | H              | H              | L              | 6          | UP           | 2F → B  | UP              | 2Q → Q  | F        | IN <sub>0</sub>  | F <sub>3</sub>   | IN <sub>0</sub> | Q <sub>3</sub>  |
| RAMU     | H              | H              | H              | 7          | UP           | 2F → B  | X               | NONE    | F        | IN <sub>0</sub>  | F <sub>3</sub>   | X               | Q <sub>3</sub>  |

X = Don't care. Electrically, the shift pin is a TTL input internally connected to a three-state output which is in the high-impedance state

B = Register Addressed by B inputs.

UP is toward MSB, DOWN is toward LSB.

Figure 4. ALU Destination Control.

| OCTAL<br>I <sub>5</sub> I <sub>4</sub> I <sub>3</sub> | OCTAL<br>I <sub>2</sub> I <sub>1</sub> I <sub>0</sub> | ALU Source<br>Function  | 0                       | 1         | 2         | 3         | 4                       | 5                       | 6         | 7    |
|---|---|-------------------------|-------------------------|-----------|-----------|-----------|-------------------------|-------------------------|-----------|------|
|   |   |                         | A, Q                    | A, B      | O, Q      | O, B      | O, A                    | D, A                    | D, Q      | D, O |
| 0   | C <sub>n</sub> = L<br>R Plus S<br>C <sub>n</sub> = H  | A + Q                   | A + B                   | Q         | B         | A         | D + A                   | D + Q                   | D         |      |
|   |   | A + Q + 1               | A + B + 1               | Q + 1     | B + 1     | A + 1     | D + A + 1               | D + Q + 1               | D + 1     |      |
| 1   | C <sub>n</sub> = L<br>S Minus R<br>C <sub>n</sub> = H | Q - A - 1               | B - A - 1               | Q - 1     | B - 1     | A - 1     | A - D - 1               | Q - D - 1               | -D - 1    |      |
|   |   | Q - A                   | B - A                   | Q         | B         | A         | A - D                   | Q - D                   | -D        |      |
| 2   | C <sub>n</sub> = L<br>R Minus S<br>C <sub>n</sub> = H | A - Q - 1               | A - B - 1               | -Q - 1    | -B - 1    | -A - 1    | D - A - 1               | D - Q - 1               | D - 1     |      |
|   |   | A - Q                   | A - B                   | -Q        | -B        | -A        | D - A                   | D - Q                   | D         |      |
| 3   | R OR S  | A ∨ Q                   | A ∨ B                   | Q         | B         | A         | D ∨ A                   | D ∨ Q                   | D         |      |
| 4   | R AND S   | A ∧ Q                   | A ∧ B                   | 0         | 0         | 0         | D ∧ A                   | D ∧ Q                   | 0         |      |
| 5   | $\bar{R}$ AND S                                       | $\bar{A} \wedge Q$      | $\bar{A} \wedge B$      | Q         | B         | A         | $\bar{D} \wedge A$      | $\bar{D} \wedge Q$      | 0         |      |
| 6   | R EX-OR S   | A ⊕ Q                   | A ⊕ B                   | Q         | B         | A         | D ⊕ A                   | D ⊕ Q                   | D         |      |
| 7   | REX-NORS  | $\overline{A \oplus Q}$ | $\overline{A \oplus B}$ | $\bar{Q}$ | $\bar{B}$ | $\bar{A}$ | $\overline{D \oplus A}$ | $\overline{D \oplus Q}$ | $\bar{D}$ |      |

+ = Plus; - = Minus; ∨ = OR; ∧ = AND; ⊕ = EX-OR

Figure 5. Source Operand and ALU Function Matrix.



## SOURCE OPERANDS AND ALU FUNCTIONS

There are eight source operand pairs available to the ALU as selected by the  $I_0$ ,  $I_1$ , and  $I_2$  instruction inputs. The ALU can perform eight functions; five logic and three arithmetic. The  $I_3$ ,  $I_4$ , and  $I_5$  instruction inputs control this function selection. The carry input,  $C_n$ , also affects the ALU results when in the arithmetic mode. The  $C_n$  input has no effect in the logic mode. When  $I_0$  through  $I_5$  and  $C_n$  are viewed together, the matrix of

Figure 5 results. This matrix fully defines the ALU/source operand function for each state.

The ALU functions can also be examined on a "task" basis, i.e., add, subtract, AND, OR, etc. In the arithmetic mode, the carry will affect the function performed while in the logic mode, the carry will have no bearing on the ALU output. Figure 6 defines the various logic operations that the Am2901 can perform and Figure 7 shows the arithmetic functions of the device. Both carry-in LOW ( $C_n = 0$ ) and carry-in HIGH ( $C_n = 1$ ) are defined in these operations.

2

| Octal<br>$I_5 I_4 I_3 I_2 I_1 I_0$ | Group  | Function   |
|------------------------------------|--------|--|
| 4 0<br>4 1<br>4 5<br>4 6           | AND    | $A \wedge Q$<br>$A \wedge B$<br>$D \wedge A$<br>$D \wedge Q$   |
| 3 0<br>3 1<br>3 5<br>3 6           | OR     | $A \vee Q$<br>$A \vee B$<br>$D \vee A$<br>$D \vee Q$   |
| 6 0<br>6 1<br>6 5<br>6 6           | EX-OR  | $A \vee Q$<br>$A \vee B$<br>$D \vee A$<br>$D \vee Q$   |
| 7 0<br>7 1<br>7 5<br>7 6           | EX-NOR | $\overline{A \vee Q}$<br>$\overline{A \vee B}$<br>$\overline{D \vee A}$<br>$\overline{D \vee Q}$         |
| 7 2<br>7 3<br>7 4<br>7 7           | INVERT | $\overline{Q}$<br>$\overline{B}$<br>$\overline{A}$<br>$\overline{D}$                                     |
| 6 2<br>6 3<br>6 4<br>6 7           | PASS   | $Q$<br>$B$<br>$A$<br>$D$   |
| 3 2<br>3 3<br>3 4<br>3 7           | PASS   | $Q$<br>$B$<br>$A$<br>$D$   |
| 4 2<br>4 3<br>4 4<br>4 7           | "ZERO" | 0<br>0<br>0<br>0   |
| 5 0<br>5 1<br>5 5<br>5 6           | MASK   | $\overline{A} \wedge Q$<br>$\overline{A} \wedge B$<br>$\overline{D} \wedge A$<br>$\overline{D} \wedge Q$ |

Figure 6. ALU Logic Mode Functions.

| Octal<br>$I_5 I_4 I_3 I_2 I_1 I_0$                   | $C_n = 0$ (Low)        |  | $C_n = 1$ (High)       |  |
|--|------------------------|--|------------------------|--|
|  | Group                  | Function   | Group                  | Function   |
| 0 0<br>0 1<br>0 5<br>0 6                             | ADD                    | $A+Q$<br>$A+B$<br>$D+A$<br>$D+Q$   | ADD plus one           | $A+Q+1$<br>$A+B+1$<br>$D+A+1$<br>$D+Q+1$                             |
| 0 2<br>0 3<br>0 4<br>0 7                             | PASS                   | $Q$<br>$B$<br>$A$<br>$D$   | Increment              | $Q+1$<br>$B+1$<br>$A+1$<br>$D+1$                                     |
| 1 2<br>1 3<br>1 4<br>2 7                             | Decrement              | $Q-1$<br>$B-1$<br>$A-1$<br>$D-1$   | PASS                   | $Q$<br>$B$<br>$A$<br>$D$   |
| 2 2<br>2 3<br>2 4<br>1 7                             | 1's Comp.              | $\overline{Q}-1$<br>$\overline{B}-1$<br>$\overline{A}-1$<br>$\overline{D}-1$         | 2's Comp.<br>(Negate)  | $\overline{Q}$<br>$\overline{B}$<br>$\overline{A}$<br>$\overline{D}$ |
| 1 0<br>1 1<br>1 5<br>1 6<br>2 0<br>2 1<br>2 5<br>2 6 | Subtract<br>(1's Comp) | $Q-A-1$<br>$B-A-1$<br>$A-D-1$<br>$Q-D-1$<br>$A-Q-1$<br>$A-B-1$<br>$D-A-1$<br>$D-Q-1$ | Subtract<br>(2's Comp) | $Q-A$<br>$B-A$<br>$A-D$<br>$Q-D$<br>$A-Q$<br>$A-B$<br>$D-A$<br>$D-Q$ |

Figure 7. ALU Arithmetic Mode Functions.

LOGIC FUNCTIONS FOR G, P, C<sub>n+4</sub>, AND OVR

The four signals G, P, C<sub>n+4</sub>, and OVR are designed to indicate carry and overflow conditions when the Am2901 is in the add or subtract mode. The table below indicates the logic equations for these four signals for each of the eight ALU functions. The R and S inputs are the two inputs selected according to Figure 2.

## Definitions (+ = OR)

$$P_0 = R_0 + S_0$$

$$G_0 = R_0 S_0$$

$$P_1 = R_1 + S_1$$

$$G_1 = R_1 S_1$$

$$P_2 = R_2 + S_2$$

$$G_2 = R_2 S_2$$

$$P_3 = R_3 + S_3$$

$$G_3 = R_3 S_3$$

$$C_4 = G_3 + P_3 G_2 + P_3 P_2 G_1 + P_3 P_2 P_1 G_0 + P_3 P_2 P_1 P_0 C_n$$

$$C_3 = G_2 + P_2 G_1 + P_2 P_1 G_0 + P_2 P_1 P_0 C_n$$

| I <sub>543</sub> | Function               | $\bar{P}$  | $\bar{G}$  | $C_{n+4}$  | OVR                                |
|------------------|------------------------|--|--|--|------------------------------------|
| 0                | R + S                  | $\overline{P_3 P_2 P_1 P_0}$   | $\overline{G_3 + P_3 G_2 + P_3 P_2 G_1 + P_3 P_2 P_1 G_0}$                       | $C_4$  | $C_3 \vee C_4$                     |
| 1                | S - R                  | ← Same as R + S equations, but substitute $\bar{R}_i$ for $R_i$ in definitions →         |  |  |                                    |
| 2                | R - S                  | ← Same as R + S equations, but substitute $\bar{S}_i$ for $S_i$ in definitions →         |  |  |                                    |
| 3                | R ∨ S                  | LOW  | $P_3 P_2 P_1 P_0$  | $\overline{P_3 P_2 P_1 P_0} + C_n$   | $\overline{P_3 P_2 P_1 P_0} + C_n$ |
| 4                | R ∧ S                  | LOW  | $\overline{G_3 + G_2 + G_1 + G_0}$   | $G_3 + G_2 + G_1 + G_0 + C_n$  | $G_3 + G_2 + G_1 + G_0 + C_n$      |
| 5                | $\bar{R} \wedge S$     | LOW  | ← Same as R ∧ S equations, but substitute $\bar{R}_i$ for $R_i$ in definitions → |  |                                    |
| 6                | R ∨ $\bar{S}$          | ← Same as $\bar{R} \vee \bar{S}$ , but substitute $\bar{R}_i$ for $R_i$ in definitions → |  |  |                                    |
| 7                | $\bar{R} \vee \bar{S}$ | $G_3 + G_2 + G_1 + G_0$  | $G_3 + P_3 G_2 + P_3 P_2 G_1 + P_3 P_2 P_1 P_0$                                  | $\overline{G_3 + P_3 G_2 + P_3 P_2 G_1 + P_3 P_2 P_1 P_0 (G_0 + \bar{C}_n)}$ | See note                           |

Note:  $[\bar{P}_2 + \bar{G}_2 \bar{P}_1 + \bar{G}_2 \bar{G}_1 \bar{P}_0 + \bar{G}_2 \bar{G}_1 \bar{G}_0 C_n] \vee [\bar{P}_3 + \bar{G}_3 \bar{P}_2 + \bar{G}_3 \bar{G}_2 \bar{P}_1 + \bar{G}_3 \bar{G}_2 \bar{G}_1 \bar{P}_0 + \bar{G}_3 \bar{G}_2 \bar{G}_1 \bar{G}_0 C_n]$

+ = OR

Figure 8.

## ORDERING INFORMATION

Order the part number according to the table below to obtain the desired package, temperature range, and screening level.

| Am2901<br>Order Number | Am2901A<br>Order Number | Am2901B<br>Order Number | Package Type<br>(Note 1) | Operating Range<br>(Note 2) | Screening Level<br>(Note 3)                          |
|------------------------|-------------------------|-------------------------|--------------------------|-----------------------------|--|
| AM2901PC               | AM2901APC               | AM2901BPC               | P-40                     | C                           | C-1  |
| AM2901DC               | AM2901ADC               | AM2901BDC               | D-40                     | C                           | C-1  |
| AM2901DC-B             | AM2901ADC-B             | AM2901BDC-B             | D-40                     | C                           | B-2 (Note 4)   |
|                        | AM2901ADM               | AM2901BDM               | D-40                     | M                           | C-3  |
|                        | AM2901ADM-B             | AM2901BDM-B             | D-40                     | M                           | B-3  |
|                        | AM2901AFM               | AM2901BFM               | F-42                     | M                           | C-3  |
|                        | AM2901AFM-B             | AM2901BFM-B             | F-42                     | M                           | B-3  |
|                        | AM2901AXC               | AM2901BXC               | Dice                     | C                           | Visual inspection<br>to MIL-STD-883<br>Method 2010B. |
|                        | AM2901AXM               | AM2901BXM               | Dice                     | M                           |  |

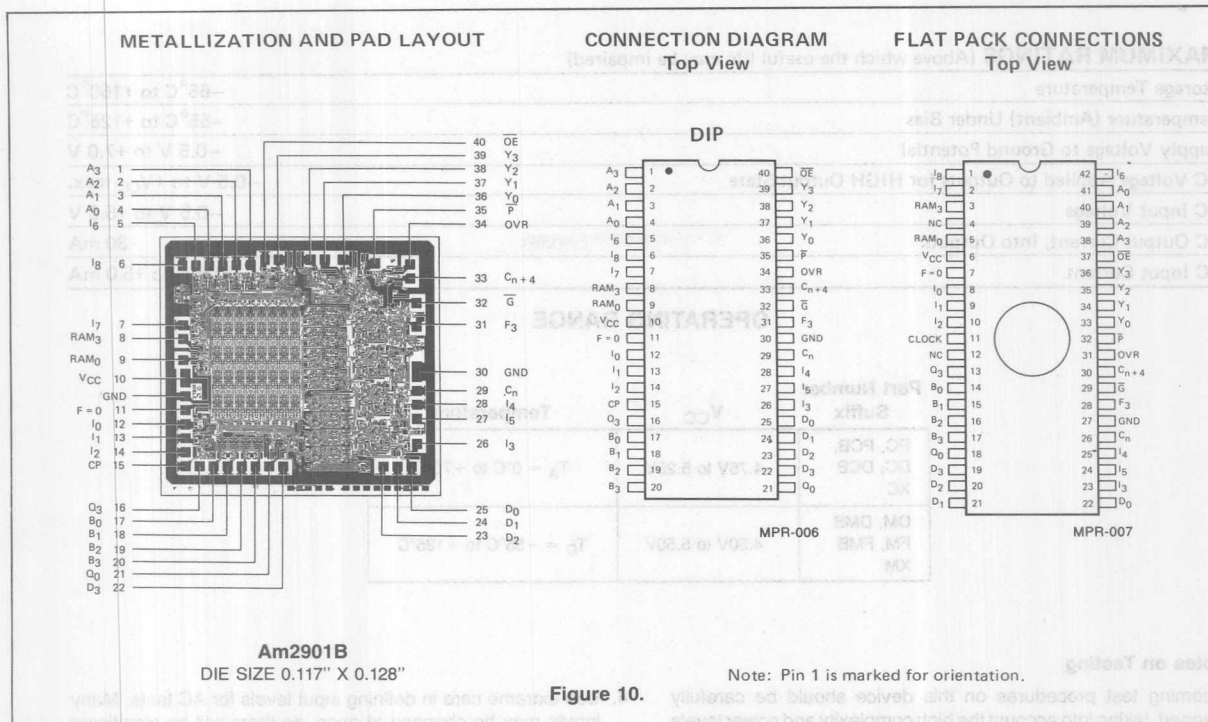
Notes: 1. P = Molded DIP, D = Hermetic DIP, F = Flat Pak. Number following letter is number of leads. See Appendix B for detailed outline. Where Appendix B contains several dash numbers, any of the variations of the package may be used unless otherwise specified.

2. C = 0°C to +70°C, V<sub>CC</sub> = 4.75V to 5.25V, M = -55°C to +125°C, V<sub>CC</sub> = 4.50V to 5.50V.

3. See Appendix A for details of screening. Levels C-1 and C-3 conform to MIL-STD-883, Class C. Level B-3 conforms to MIL-STD-883, Class B.

4. 96 hour burn-in.

Figure 9.



Note: Pin 1 is marked for orientation.

#### PIN DEFINITIONS

- A<sub>0-3</sub>** The four address inputs to the register stack used to select one register whose contents are displayed through the A-port.
- B<sub>0-3</sub>** The four address inputs to the register stack used to select one register whose contents are displayed through the B-port and into which new data can be written when the clock goes LOW.
- I<sub>0-8</sub>** The nine instruction control lines. Used to determine what data sources will be applied to the ALU (I<sub>012</sub>), what function the ALU will perform (I<sub>345</sub>), and what data is to be deposited in the Q-register or the register stack (I<sub>678</sub>).
- Q<sub>3</sub>** A shift line at the MSB of the Q register (Q<sub>3</sub>) and the register stack (RAM<sub>3</sub>). Electrically these lines are three-state outputs connected to TTL inputs internal to the device. When the destination code on I<sub>678</sub> indicates an up shift (octal 6 or 7) the three-state outputs are enabled and the MSB of the Q register is available on the Q<sub>3</sub> pin and the MSB of the ALU output is available on the RAM<sub>3</sub> pin. Otherwise, the three-state outputs are OFF (high-impedance) and the pins are electrically LS-TTL inputs. When the destination code calls for a down shift, the pins are used as the data inputs to the MSB of the Q register (octal 4) and RAM (octal 4 or 5).
- Q<sub>0</sub>** Shift lines like Q<sub>3</sub> and RAM<sub>3</sub>, but at the LSB of the Q-register and RAM. These pins are tied to the Q<sub>3</sub> and RAM<sub>3</sub> pins of the adjacent device to transfer data between devices for up and down shifts of the Q register and ALU data.
- RAM<sub>0</sub>**
- D<sub>0-3</sub>** Direct data inputs. A four-bit data field which may be selected as one of the ALU data sources for entering data into the device. D<sub>0</sub> is the LSB.

- Y<sub>0-3</sub>** The four data outputs. These are three-state output lines. When enabled, they display either the four outputs of the ALU or the data on the A-port of the register stack, as determined by the destination code I<sub>678</sub>.
- OE** Output Enable. When OE is HIGH, the Y outputs are OFF; when OE is LOW, the Y outputs are active (HIGH or LOW).
- G, P** The carry generate and propagate outputs of the internal ALU. These signals are used with the Am2902 for carry-lookahead.
- OVR** Overflow. This pin is logically the Exclusive-OR of the carry-in and carry-out of the MSB of the ALU. At the most significant end of the word, this pin indicates that the result of an arithmetic two's complement operation has overflowed into the sign-bit.
- F = 0** This is an open collector output which goes HIGH (OFF) if the data on the four ALU outputs F<sub>0-3</sub> are all LOW. In positive logic, it indicates the result of an ALU operation is zero.
- F<sub>3</sub>** The most significant ALU output bit.
- C<sub>n</sub>** The carry-in to the internal ALU.
- C<sub>n+4</sub>** The carry-out of the internal ALU.
- CP** The clock input. The Q register and register stack outputs change on the clock LOW-to-HIGH transition. The clock LOW time is internally the write enable to the 16 x 4 RAM which comprises the "master" latches of the register stack. While the clock is LOW, the "slave" latches on the RAM outputs are closed, storing the data previously on the RAM outputs. This allows synchronous master-slave operation of the register stack.



**MAXIMUM RATINGS** (Above which the useful life may be impaired)

|   |                                 |
|---|---------------------------------|
| Storage Temperature                                 | -65°C to +150°C                 |
| Temperature (Ambient) Under Bias                    | -55°C to +125°C                 |
| Supply Voltage to Ground Potential                  | -0.5 V to +7.0 V                |
| DC Voltage Applied to Outputs for HIGH Output State | -0.5 V to +V <sub>CC</sub> max. |
| DC Input Voltage                                    | -0.5 V to +5.5 V                |
| DC Output Current, Into Outputs                     | 30 mA                           |
| DC Input Current                                    | -30 mA to +5.0 mA               |

**OPERATING RANGE**

| Part Number<br>Suffix     | V <sub>CC</sub> | Temperature                      |
|---------------------------|-----------------|----------------------------------|
| PC, PCB,<br>DC, DCB<br>XC | 4.75V to 5.25V  | T <sub>A</sub> = 0°C to +70°C    |
| DM, DMB<br>FM, FMB<br>XM  | 4.50V to 5.50V  | T <sub>C</sub> = -55°C to +125°C |

**Notes on Testing**

Incoming test procedures on this device should be carefully planned, taking into account the high complexity and power levels of the part. The following notes may be useful.

1. Insure the part is adequately decoupled at the test head. Large changes in V<sub>CC</sub> current as the device switches may cause erroneous function failures due to V<sub>CC</sub> changes.
2. Do not leave inputs floating during any tests, as they may start to oscillate at high frequency.
3. Do not attempt to perform threshold tests at high speed. Following an input transition, ground current may change by as much as 400mA in 5-8ns. Inductance in the ground cable may allow the ground pin at the device to rise by 100's of millivolts momentarily.
4. Use extreme care in defining input levels for AC tests. Many inputs may be changed at once, so there will be significant noise at the device pins and they may not actually reach V<sub>IL</sub> or V<sub>IH</sub> until the noise has settled. AMD recommends using V<sub>IL</sub> ≤ 0.4V and V<sub>IH</sub> ≥ 2.4V for AC tests.
5. To simplify failure analysis, programs should be designed to perform DC, Function, and AC tests as three distinct groups of tests.
6. To assist in testing, AMD offers complete documentation on our test procedures and, in most cases, can provide Fairchild Sentry programs, under license.

## (Group A, Subgroups 1, 2, and 3)

| Parameters             | Description                                  | Test Conditions (Note 1)   |                                       | Min.  | Typ.<br>(Note 2) | Max.  | Units         |
|------------------------|--|--|---------------------------------------|---|------------------|-------|---------------|
| $V_{OH}$               | Output HIGH Voltage                          | $V_{CC} = \text{MIN.}$<br>$V_{IN} = V_{IH} \text{ or } V_{IL}$                       |                                       | $I_{OH} = -1.6\text{mA}$<br>$Y_0, Y_1, Y_2, Y_3$          | 2.4              |       | Volts         |
|                        |  |  |                                       | $I_{OH} = -1.0\text{mA}, C_{n+4}$                         | 2.4              |       |               |
|                        |  |  |                                       | $I_{OH} = -800\mu\text{A}, \text{OVR}, \bar{P}$           | 2.4              |       |               |
|                        |  |  |                                       | $I_{OH} = -600\mu\text{A}, F_3$                           | 2.4              |       |               |
|                        |  |  |                                       | $I_{OH} = -600\mu\text{A}$<br>$\text{RAM}_{0,3}, Q_{0,3}$ | 2.4              |       |               |
|                        |  |  |                                       | $I_{OH} = -1.6\text{mA}, \bar{G}$                         | 2.4              |       |               |
| $I_{CEX}$              | Output Leakage Current<br>for $F = 0$ Output | $V_{CC} = \text{MIN.}, V_{OH} = 5.5\text{V}$<br>$V_{IN} = V_{IH} \text{ or } V_{IL}$ |                                       |   |                  | 250   | $\mu\text{A}$ |
| $V_{OL}$               | Output LOW Voltage                           | $V_{CC} = \text{MIN.},$<br>$V_{IN} = V_{IH}$<br>or $V_{IL}$                          | $Y_0, Y_1, Y_2, Y_3$                  | $I_{OL} = 20\text{mA (COM'L)}$                            |                  | 0.5   | Volts         |
|                        |  |  |                                       | $I_{OL} = 16\text{mA (MIL)}$                              |                  | 0.5   |               |
|                        |  |  | $\bar{G}, F = 0$                      | $I_{OL} = 16\text{mA}$                                    |                  | 0.5   |               |
|                        |  |  | $C_{n+4}$                             | $I_{OL} = 10\text{mA}$                                    |                  | 0.5   |               |
|                        |  |  | $\text{OVR}, \bar{P}$                 | $I_{OL} = 8.0\text{mA}$                                   |                  | 0.5   |               |
|                        |  |  | $F_3, \text{RAM}_{0,3},$<br>$Q_{0,3}$ | $I_{OL} = 6.0\text{mA}$                                   |                  | 0.5   |               |
| $V_{IH}$               | Input HIGH Level                             | Guaranteed input logical HIGH<br>voltage for all inputs (Note 7)                     |                                       | 2.0   |                  |       | Volts         |
| $V_{IL}$               | Input LOW Level                              | Guaranteed input logical LOW<br>voltage for all inputs (Note 7)                      |                                       |   |                  | 0.8   | Volts         |
| $V_I$                  | Input Clamp Voltage                          | $V_{CC} = \text{MIN.}, I_{IN} = -18\text{mA}$  |                                       |   |                  | -1.5  | Volts         |
| $I_{IL}$               | Input LOW Current                            | $V_{CC} = \text{MAX.}, V_{IN} = 0.5\text{V}$   | Clock, $\bar{OE}$                     |   |                  | -0.36 | $\text{mA}$   |
|                        |  |  | $A_0, A_1, A_2, A_3$                  |   |                  | -0.36 |               |
|                        |  |  | $B_0, B_1, B_2, B_3$                  |   |                  | -0.36 |               |
|                        |  |  | $D_0, D_1, D_2, D_3$                  |   |                  | -0.72 |               |
|                        |  |  | $I_0, I_1, I_2, I_6, I_8$             |   |                  | -0.36 |               |
|                        |  |  | $I_3, I_4, I_5, I_7$                  |   |                  | -0.72 |               |
|                        |  |  | $\text{RAM}_{0,3}, Q_{0,3}$ (Note 4)  |   |                  | -0.8  |               |
|                        |  |  | $C_n$                                 |   |                  | -3.6  |               |
| $I_{IH}$               | Input HIGH Current                           | $V_{CC} = \text{MAX.}, V_{IN} = 2.7\text{V}$   | Clock, $\bar{OE}$                     |   |                  | 20    | $\mu\text{A}$ |
|                        |  |  | $A_0, A_1, A_2, A_3$                  |   |                  | 20    |               |
|                        |  |  | $B_0, B_1, B_2, B_3$                  |   |                  | 20    |               |
|                        |  |  | $D_0, D_1, D_2, D_3$                  |   |                  | 40    |               |
|                        |  |  | $I_0, I_1, I_2, I_6, I_8$             |   |                  | 20    |               |
|                        |  |  | $I_3, I_4, I_5, I_7$                  |   |                  | 40    |               |
|                        |  |  | $\text{RAM}_{0,3}, Q_{0,3}$ (Note 4)  |   |                  | 100   |               |
|                        |  |  | $C_n$                                 |   |                  | 200   |               |
| $I_I$                  | Input HIGH Current                           | $V_{CC} = \text{MAX.}, V_{IN} = 5.5\text{V}$   |                                       |   |                  | 1.0   | $\text{mA}$   |
| $I_{OZH}$<br>$I_{OZL}$ | Off State (High Impedance)<br>Output Current | $V_{CC} = \text{MAX.}$   | $Y_0, Y_1,$<br>$Y_2, Y_3$             | $V_O = 2.4\text{V}$                                       |                  | 50    | $\mu\text{A}$ |
|                        |  |  |                                       | $V_O = 0.5\text{V}$                                       |                  | -50   |               |
|                        |  |  | $\text{RAM}_{0,3}$<br>$Q_{0,3}$       | $V_O = 2.4\text{V}$<br>(Note 4)                           |                  | 100   |               |
|                        |  |  |                                       | $V_O = 0.5\text{V}$<br>(Note 4)                           |                  | -800  |               |
| $I_{OS}$               | Output Short Circuit Current<br>(Note 3)     | $V_{CC} = \text{MAX.} + 0.5\text{V}, V_O = 0.5\text{V}$                              | $Y_0, Y_1, Y_2, Y_3, \bar{G}$         |   | -30              | -85   | $\text{mA}$   |
|                        |  |  | $C_{n+4}$                             |   | -30              | -85   |               |
|                        |  |  | $\text{OVR}, \bar{P}$                 |   | -30              | -85   |               |
|                        |  |  | $F_3$                                 |   | -30              | -85   |               |
|                        |  |  | $\text{RAM}_{0,3}, Q_{0,3}$           |   | -30              | -85   |               |
| $I_{CC}$               | Power Supply Current<br>(Note 6)             | $V_{CC} = \text{MAX.}$<br>(See Fig. 11)  | COM'L and MIL                         | $T_A = 25^\circ\text{C}$                                  | 160              | 250   | $\text{mA}$   |
|                        |  |  | COM'L Only                            | $T_A = 0^\circ\text{C to } +70^\circ\text{C}$             |                  | 265   |               |
|                        |  |  |                                       | $T_A = +70^\circ\text{C}$                                 |                  | 220   |               |
|                        |  |  | MIL Only                              | $T_C = -55^\circ\text{C to } +125^\circ\text{C}$          |                  | 280   |               |
|                        |  |  |                                       | $T_C = +125^\circ\text{C}$                                |                  | 198   |               |

Notes: 1. For conditions shown as MIN. or MAX., use the appropriate value specified under Electrical Characteristics for the applicable device type.

2. Typical limits are at  $V_{CC} = 5.0\text{V}$ ,  $25^\circ\text{C}$  ambient and maximum loading.

3. Not more than one output should be shorted at a time. Duration of the short circuit test should not exceed one second.

4. These are three-state outputs internally connected to TTL inputs. Input characteristics are measured with  $I_{678}$  in a state such that the three-state output is OFF.

5. "MIL" = Am2901XM, DM, FM. "COM'L" = Am2901XC, PC, DC.

6. Worst case  $I_{CC}$  is at minimum temperature.

7. These input levels provide zero noise immunity and should only be tested in a static, noise-free environment.

# I. Am2901B Guaranteed Commercial Range Performance

The tables below specify the guaranteed performance of the Am2901B over the commercial operating range of 0°C to +70°C, with  $V_{CC}$  from 4.75V to 5.25V. All data are in ns, with inputs switching between 0V and 3V at 1V/ns and measurements made at 1.5V. All outputs have maximum DC load.


This data applies to the following part numbers: Am2901BPC  
Am2901BDC

## A. Cycle Time and Clock Characteristics.


|   |       |
|---|-------|
| Read-Modify-Write Cycle (from selection of A, B registers to end of cycle.) | 69ns  |
| Maximum Clock Frequency to shift Q (50% duty cycle, I = 432 or 632)         | 16MHz |
| Minimum Clock LOW Time  | 30ns  |
| Minimum Clock HIGH Time   | 30ns  |
| Minimum Clock Period  | 69ns  |

## B. Combinational Propagation Delays.

$C_L = 50\text{pF}$

| To Output<br>From Input   | Y  | F3 | Cn+4 | $\overline{G}, \overline{P}$ | F=0 | OVR | RAM0<br>RAM3 | Q0<br>Q3 |
|---|----|----|------|------------------------------|-----|-----|--------------|----------|
| A, B Address  | 60 | 61 | 59   | 50                           | 70  | 67  | 71           | —        |
| D   | 38 | 36 | 40   | 33                           | 48  | 44  | 45           | —        |
| Cn  | 30 | 29 | 20   | —                            | 37  | 29  | 38           | —        |
| I012  | 50 | 47 | 45   | 45                           | 56  | 53  | 57           | —        |
| I345  | 51 | 52 | 52   | 45                           | 60  | 49  | 53           | —        |
| I678  | 28 | —  | —    | —                            | —   | —   | 27           | 27       |
| A Bypass ALU<br>(I = 2XX)   | 37 | —  | —    | —                            | —   | —   | —            | —        |
| Clock  | 49 | 48 | 47   | 37                           | 58  | 55  | 59           | 29       |

## C. Set-up and Hold Times Relative to Clock (CP) Input.

| Input                 | CP:  |                          |                             |                          |
|-----------------------|---|--------------------------|-----------------------------|--------------------------|
|                       | Set-up Time<br>Before H → L   | Hold Time<br>After H → L | Set-up Time<br>Before L → H | Hold Time<br>After L → H |
| A, B Source Address   | 20  | 0 (Note 3)               | 69 (Note 4)                 | 0                        |
| B Destination Address | 15  | Do Not Change            |                             | 0                        |
| D                     | —   | —                        | 51                          | 0                        |
| Cn                    | —   | —                        | 39                          | 0                        |
| I012                  | —   | —                        | 56                          | 0                        |
| I345                  | —   | —                        | 55                          | 0                        |
| I678                  | 11  | Do Not Change            |                             | 0                        |
| RAM0, 3, Q0, 3        | —   | —                        | 16                          | 0                        |

## D. Output Enable/Disable Times.

Output disable tests performed with  $C_L = 5\text{pF}$  and measured to 0.5V change of output voltage level.

| Input           | Output | Enable | Disable |
|-----------------|--------|--------|---------|
| $\overline{OE}$ | Y      | 35     | 25      |

Notes: 1. A dash indicates a propagation delay path or set-up time constraint does not exist.

2. Certain signals must be stable during the entire clock LOW time to avoid erroneous operation. This is indicated by the phrase "do not change".

3. Source addresses must be stable prior to the clock H → L transition to allow time to access the source data before the latches close. The A address may then be changed. The B address could be changed if it is not a destination; i.e. if data is not being written back into the RAM. **Normally A and B are not changed during the clock LOW time.**

4. The set-up time prior to the clock L → H transition is to allow time for data to be accessed, passed through the ALU, and returned to the RAM. It includes all the time from stable A and B addresses to the clock L → H transition, regardless of when the clock H → L transition occurs.



## II. Am2901B Guaranteed Military Range Performance


The tables below specify the guaranteed performance of the Am2901B over the military operating range of  $-55^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ , with  $V_{\text{CC}}$  from 4.5V to 5.5V. All data are in ns, with inputs switching between 0V and 3V at 1V/ns and measurements made at 1.5V. All outputs have maximum DC load.

This data applies to the following part numbers: Am2901BDM  
Am2901BFM

### A. Cycle Time and Clock Characteristics.

|  |       |
|--|-------|
| Read-Modify-Write Cycle (from selection of A, B registers to end of cycle. | 88ns  |
| Maximum Clock Frequency to shift Q (50% duty cycle, $I = 432$ or 632)      | 15MHz |
| Minimum Clock LOW Time   | 30ns  |
| Minimum Clock HIGH Time  | 30ns  |
| Minimum Clock Period   | 88ns  |

### B. Combinational Propagation Delays. $C_L = 50\text{pF}$

| To Output<br>From Input   | Y  | F3 | Cn+4 | $\bar{G}, \bar{P}$ | F=0 | OVR | RAM0<br>RAM3 | Q0<br>Q3 |
|---|----|----|------|--------------------|-----|-----|--------------|----------|
| A, B Address  | 82 | 84 | 80   | 70                 | 90  | 86  | 94           | —        |
| D   | 44 | 38 | 40   | 34                 | 50  | 45  | 48           | —        |
| Cn  | 34 | 32 | 24   | —                  | 38  | 31  | 39           | —        |
| I012  | 53 | 50 | 47   | 46                 | 65  | 55  | 58           | —        |
| I345  | 58 | 58 | 58   | 48                 | 64  | 56  | 55           | —        |
| I678  | 29 | —  | —    | —                  | —   | —   | 27           | 27       |
| A Bypass ALU<br>( $I = 2XX$ )   | 50 | —  | —    | —                  | —   | —   | —            | —        |
| Clock  | 53 | 50 | 49   | 41                 | 63  | 58  | 61           | 31       |

### C. Set-up and Hold Times Relative to Clock (CP) Input.

| Input                 | CP:<br>Set-up Time<br>Before H $\rightarrow$ L | Hold Time<br>After H $\rightarrow$ L | Set-up Time<br>Before L $\rightarrow$ H | Hold Time<br>After L $\rightarrow$ H |
|-----------------------|--|--------------------------------------|---|--------------------------------------|
| A, B Source Address   | 30   | 0 (Note 3)                           | 88 (Note 4)                             | 0                                    |
| B Destination Address | 15   | Do Not Change                        |   | 0                                    |
| D                     | —  | —                                    | 55                                      | 0                                    |
| Cn                    | —  | —                                    | 42                                      | 0                                    |
| I012                  | —  | —                                    | 58                                      | 0                                    |
| I345                  | —  | —                                    | 62                                      | 0                                    |
| I678                  | 14   | Do Not Change                        |   | 0                                    |
| RAM0, 3, Q0, 3        | —  | —                                    | 18                                      | 3                                    |

### D. Output Enable/Disable Times.

Output disable tests performed with  $C_L = 5\text{pF}$  and measured to 0.5V change of output voltage level.

| Input      | Output | Enable | Disable |
|------------|--------|--------|---------|
| $\bar{OE}$ | Y      | 40     | 25      |

Notes: 1. A dash indicates a propagation delay path or set-up time constraint does not exist.

2. Certain signals must be stable during the entire clock LOW time to avoid erroneous operation. This is indicated by the phrase "do not change".

3. Source addresses must be stable prior to the clock  $H \rightarrow L$  transition to allow time to access the source data before the latches close. The A address may then be changed. The B address could be changed if it is not a destination; i.e. if data is not being written back into the RAM. **Normally A and B are not changed during the clock LOW time.**

4. The set-up time prior to the clock  $L \rightarrow H$  transition is to allow time for data to be accessed, passed through the ALU, and returned to the RAM. It includes all the time from stable A and B addresses to the clock  $L \rightarrow H$  transition, regardless of when the clock  $H \rightarrow L$  transition occurs.

The Am2901B meets or exceeds all of the specifications for the earlier Am2901A.

Parts may still be ordered and marked as Am2901A.

|                         |      |
|-------------------------|------|
| Maximum Clock LOW Time  | 30ns |
| Minimum Clock HIGH Time | 30ns |
| Minimum Clock Period    | 50ns |

#### 5. Combinational Propagation Delays

$C_L = 50pF$

### IV. Am2901A Guaranteed Military Range Performance

The Am2901B meets or exceeds all of the specifications for the earlier Am2901A.

Parts may still be ordered and marked as Am2901A.

| Input | Output | Propagation Delay (ns) | Setup Time (ns) | Hold Time (ns) | Input | Output | Propagation Delay (ns) | Setup Time (ns) | Hold Time (ns) |
|-------|--------|------------------------|-----------------|----------------|-------|--------|------------------------|-----------------|----------------|
| 0     | 0      | 44                     | 30              | 30             | 0     | 0      | 44                     | 30              | 30             |
| 0     | 1      | 34                     | 30              | 30             | 0     | 1      | 34                     | 30              | 30             |
| 1     | 0      | 33                     | 30              | 30             | 1     | 0      | 33                     | 30              | 30             |
| 1     | 1      | 33                     | 30              | 30             | 1     | 1      | 33                     | 30              | 30             |
| 0     | 0      | 33                     | 30              | 30             | 0     | 0      | 33                     | 30              | 30             |
| 0     | 1      | 33                     | 30              | 30             | 0     | 1      | 33                     | 30              | 30             |
| 1     | 0      | 33                     | 30              | 30             | 1     | 0      | 33                     | 30              | 30             |
| 1     | 1      | 33                     | 30              | 30             | 1     | 1      | 33                     | 30              | 30             |

### V. Am2901 Guaranteed Commercial Range Performance

The Am2901B meets or exceeds all of the specifications of the Am2901.

Parts may still be ordered and marked as Am2901.

| Input | Output | Propagation Delay (ns) | Setup Time (ns) | Hold Time (ns) | Input | Output | Propagation Delay (ns) | Setup Time (ns) | Hold Time (ns) |
|-------|--------|------------------------|-----------------|----------------|-------|--------|------------------------|-----------------|----------------|
| 0     | 0      | 44                     | 30              | 30             | 0     | 0      | 44                     | 30              | 30             |
| 0     | 1      | 34                     | 30              | 30             | 0     | 1      | 34                     | 30              | 30             |
| 1     | 0      | 33                     | 30              | 30             | 1     | 0      | 33                     | 30              | 30             |
| 1     | 1      | 33                     | 30              | 30             | 1     | 1      | 33                     | 30              | 30             |

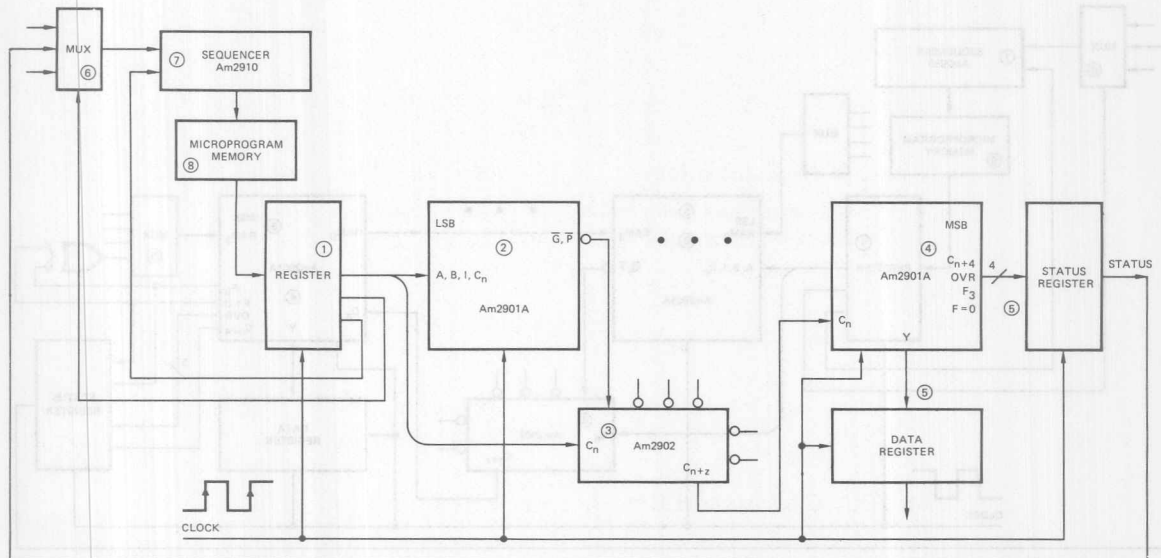
#### B. Output Enable/Disable Times

Output disable tests performed with  $C_L = 50pF$  and measured to 0.5V change of output voltage level.

| Input | Output | Enable | Disable |
|-------|--------|--------|---------|
| 0     | Y      | 40     | 40      |

## MINIMUM CYCLE TIME CALCULATIONS FOR 16-BIT SYSTEMS

Speeds used in calculations for parts other than Am2901B are representative for available MSI parts.



MPR-010

Pipelined System. Add without Simultaneous Shift.

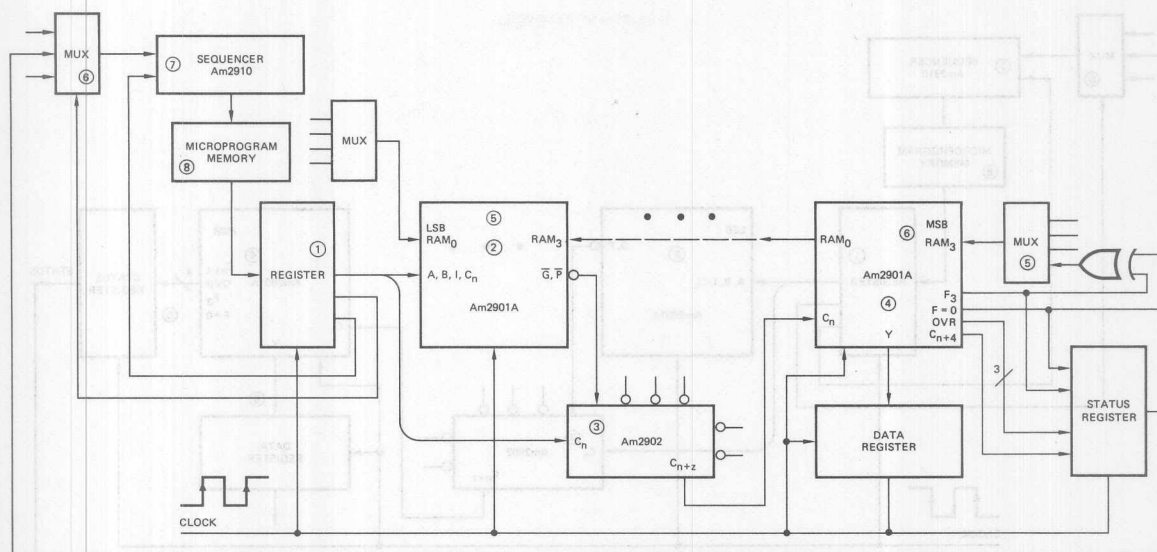
| DATA LOOP    |   |       | CONTROL LOOP |                  |       |
|--------------|---|-------|--------------|------------------|-------|
| ① Register   | Clock to Output   | 15    | ① Register   | Clock to Output  | 15    |
| + ② 2901B    | A, B to $\bar{G}$ , $\bar{P}$                                       | 50    | + ⑥ MUX      | Select to Output | 20    |
| + ③ 2902     | $\bar{G}_0$ , $\bar{P}_0$ to C <sub>n+z</sub>                       | 10    | + ⑦ 2910     | CC to Output     | 45    |
| + ④ 2901B    | C <sub>n</sub> to C <sub>n+4</sub> , OVR, F <sub>3</sub> , F = 0, Y | 37    | + ⑧ PROM     | Access Time      | 55    |
| + ⑤ Register | Set-up Time   | 5     | + ① Register | Set-up Time      | 5     |
|              |   | 117ns |              |                  | 140ns |

Minimum clock period = 140ns

Figure 12.

## MINIMUM CYCLE TIME CALCULATIONS FOR 16-BIT SYSTEMS (Cont.)

Speeds used in calculations for parts other than Am2901B are representative for available MSI parts.



MPR-011

## Pipelined System. Simultaneous Add and Shift Down.

## DATA LOOP

|                 |                                   |       |
|-----------------|-----------------------------------|-------|
| ① Register      | Clock to Output                   | 15    |
| + ② 2901B       | A, B to $\bar{G}$ , $\bar{P}$     | 50    |
| + ③ 2902        | $\bar{G}_0\bar{P}_0$ to $C_{n+z}$ | 10    |
| + ④ 2901B       | $C_n$ to $F_3$ , OVR              | 29    |
| + ⑤ XOR and MUX |                                   | 21    |
| + ⑥ 2901B       | RAM <sub>3</sub> Set-up           | 16    |
|                 |                                   | 141ns |

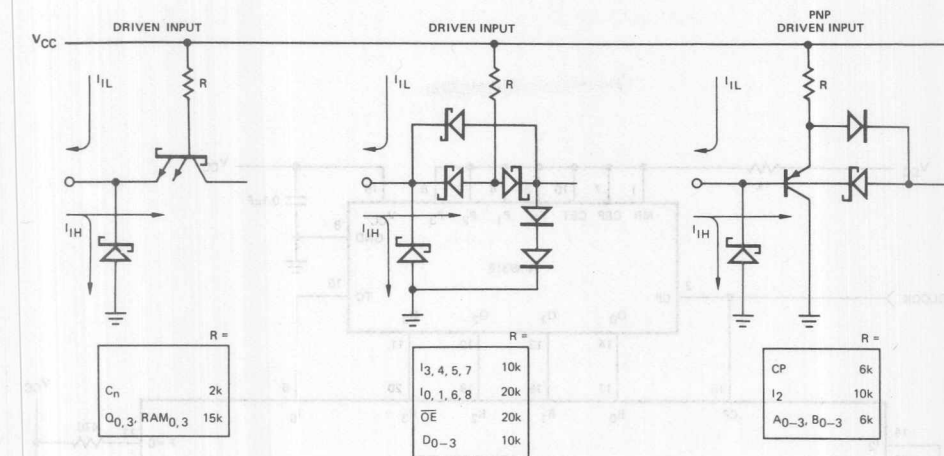
## CONTROL LOOP

|              |                  |       |
|--------------|------------------|-------|
| ① Register   | Clock to Output  | 15    |
| + ⑥ MUX      | Select to Output | 20    |
| + ⑦ 2910     | CC to Output     | 45    |
| + ⑧ PROM     | Access Time      | 55    |
| + ① Register | Set-up Time      | 5     |
|              |                  | 140ns |

Minimum clock period = 141ns

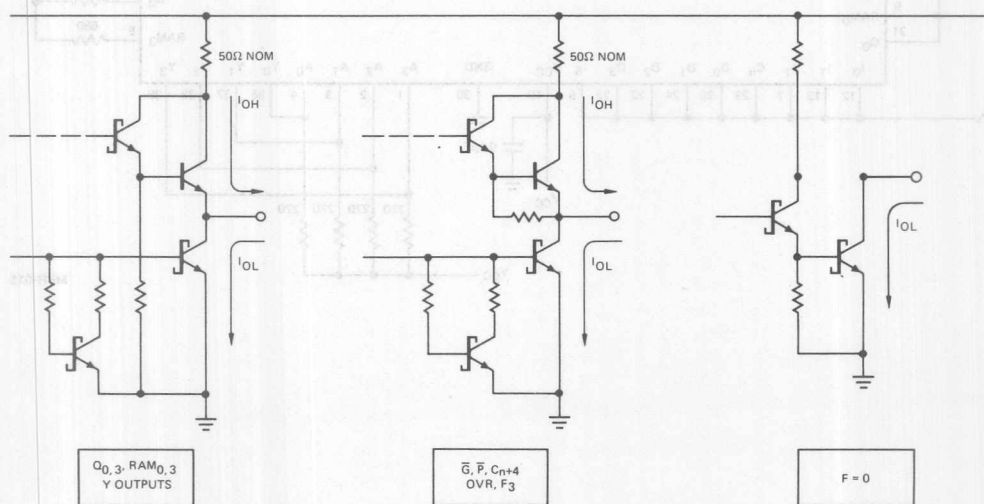
Figure 12 (Cont.).





$C_L \approx 5.0\text{pF}$ , all inputs

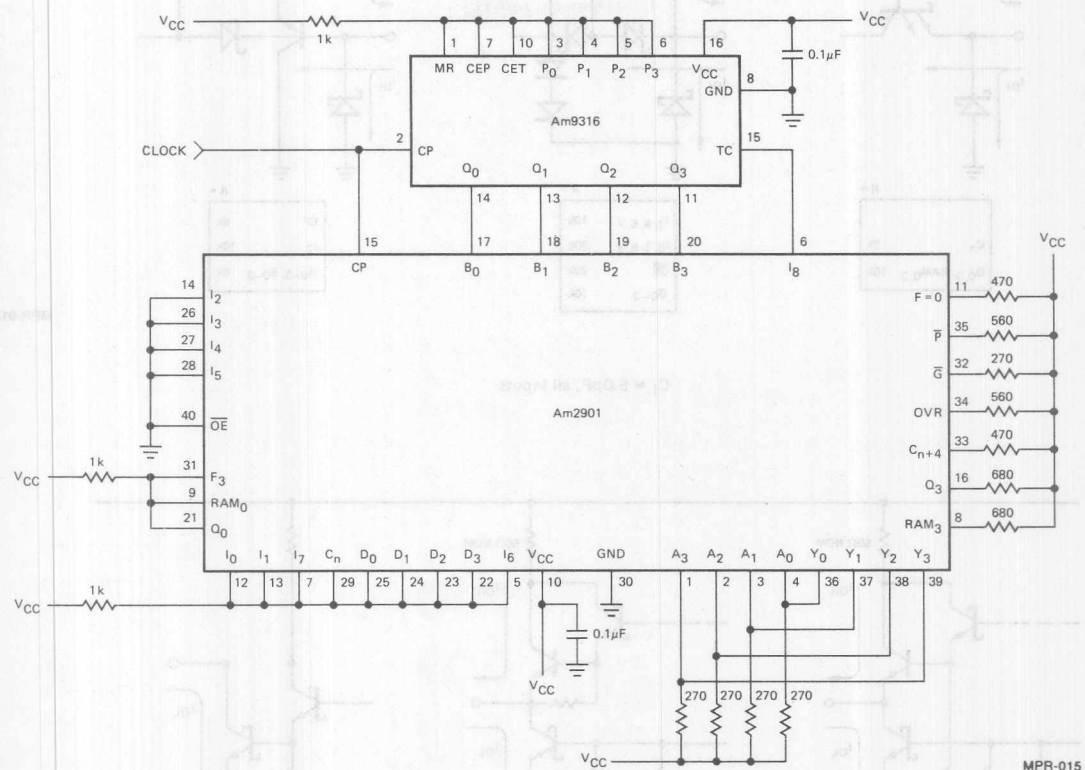
MPR-013



$C_O \approx 5.0\text{pF}$ , all outputs

MPR-014

Figure 13. Input/Output Current Interface Conditions.



V<sub>CC</sub> = 5.0V  
Frequency = 100KHz  
T<sub>A</sub> = 125°C

This circuit conforms to MIL-STD-883, method 1015, condition D.

Figure 14. Life Test and Burn-in Circuit for Military Class B Parts.  
(Contact Factory for Commercial Burn-in Conditions)

# USING THE Am2901

## BASIC SYSTEM ARCHITECTURE

The Am2901 is designed to be used in microprogrammed systems. Figure 15 illustrates such an architecture. The nine instruction lines, the A and B addresses, and the D data inputs normally will all come from registers clocked at the same time as the Am2901. The register inputs come from a ROM or PROM — the "microprogram store". This memory contains sequences of microinstructions, typically 28 to 40 bits wide, which apply the proper control signals to the Am2901's and other circuits to execute the desired operation.

The address lines of the microprogram store are driven from the Am2910 microprogram sequencer. This device has facilities for storing an address, incrementing an address, jumping to any address, and linking subroutines. The Am2910 is controlled by some of the bits coming from the microprogram store. Essentially these bits are the "next instruction" control.

Note that with the microprogram register in-between the microprogram memory store and the Am2901's, an instruction accessed on one cycle is executed on the next cycle. As one instruction is executed, the next instruction is being read from microprogram memory. In this configuration, system speed is improved because the execution time in the Am2901's occurs in parallel with the access time of the microprogram store. Without the "pipeline register", these two functions must occur serially.

## EXPANSION OF THE Am2901

The Am2901 is a four-bit CPU slice. Any number of Am2901's can be interconnected to form CPU's of 12, 16, 24, 36 or more bits, in four-bit increments. Figure 16 illustrates the interconnection of three Am2901's to form a 12-bit CPU, using ripple carry. Figure 17 illustrates a 16-bit CPU using carry lookahead, and Figure 18 is the general carry lookahead scheme for long words.

With the exception of the carry interconnection, all expansion schemes are the same. Refer to Figure 16. The Q<sub>3</sub> and RAM<sub>3</sub> pins are bidirectional left/right shift lines at the MSB of the device. For all devices except the most significant, these lines are connected to the Q<sub>0</sub> and RAM<sub>0</sub> pins of the adjacent more

significant device. These connections allow the Q-registers of all Am2901's to be shifted left or right as a contiguous n-bit register, and also allow the ALU output data to be shifted left or right as a contiguous n-bit word prior to storage in the RAM. At the LSB and MSB of the CPU, the shift pins should be connected to three-state multiplexers which can be controlled by the microcode to select the appropriate input signals to the shift inputs. (See Figure 19)

The open collector F = 0 outputs of all the Am2901's are connected together and to a pull-up resistor. This line will go HIGH if and only if the output of the ALU contains all zeroes. Most systems will use this line as the Z (zero) bit of the processor status word.

The overflow and F<sub>3</sub> pins are generally used only at the most significant end of the array, and are meaningful only when two's complement signed arithmetic is used. The overflow pin is the Exclusive-OR of the carry-in and carry-out of the sign bit (MSB). It will go HIGH when the result of an arithmetic

2

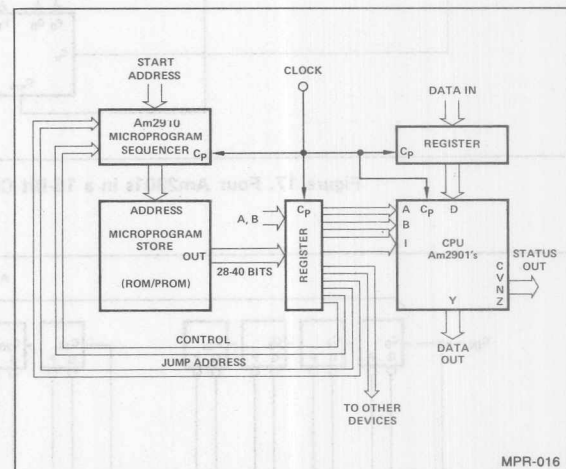


Figure 15. Microprogrammed Architecture Around Am2901's.

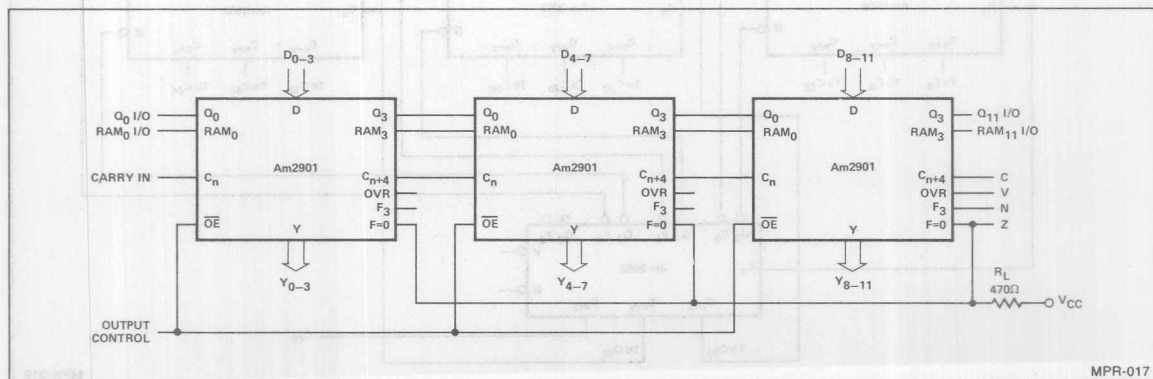


Figure 16. Three Am2901's used to Construct 12-Bit CPU with Ripple Carry. Corresponding A, B, and I Pins on all Devices are Connected Together.

operation is a number requiring more bits than are available, causing the sign bit to be erroneous. This is the overflow (V) bit of the processor status word. The  $F_3$  pin is the MSB of the ALU output. It is the sign of the result in two's complement notation, and should be used as the Negative (N) bit of the processor status word.

The carry-out from the most significant Am2901 ( $C_{n+4}$  pin) is the carry-out from the array, and is used as the carry (C) bit of the processor status word.

Carry interconnections between devices may use either ripple carry or carry lookahead. For ripple carry, the carry-out ( $C_{n+4}$ ) of each device is connected to the carry-in ( $C_n$ ) of the next more significant device. Carry lookahead uses the Am2902 lookahead carry generator. The scheme is identical to that used with the 74181/74182. Users unfamiliar with this technique should refer to AMD's application note on Arithmetic Logic Units. Figures 17 and 18 illustrate single and multiple level lookahead.

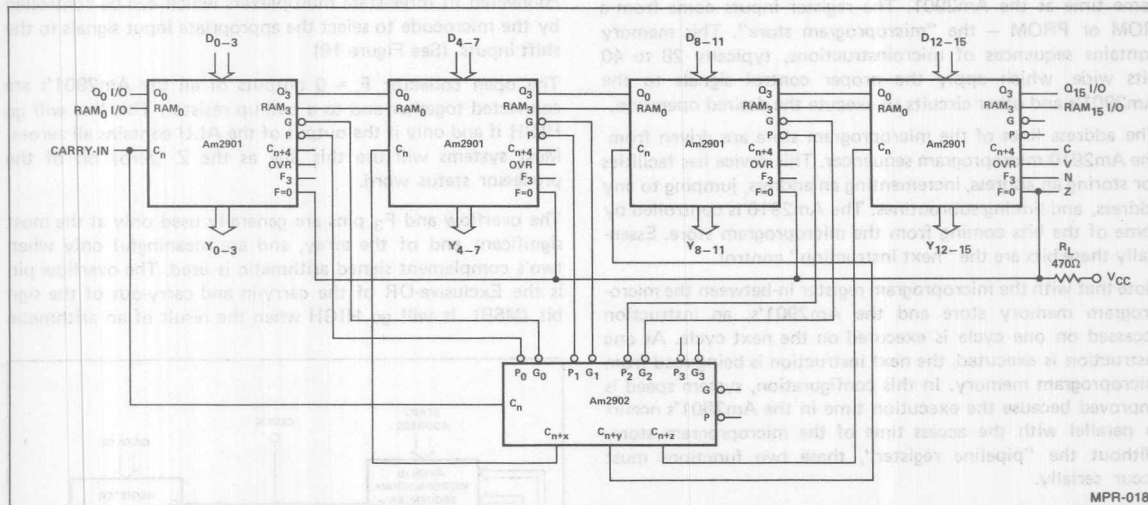


Figure 17. Four Am2901s in a 16-Bit CPU Using the Am2902 for Carry Lookahead.

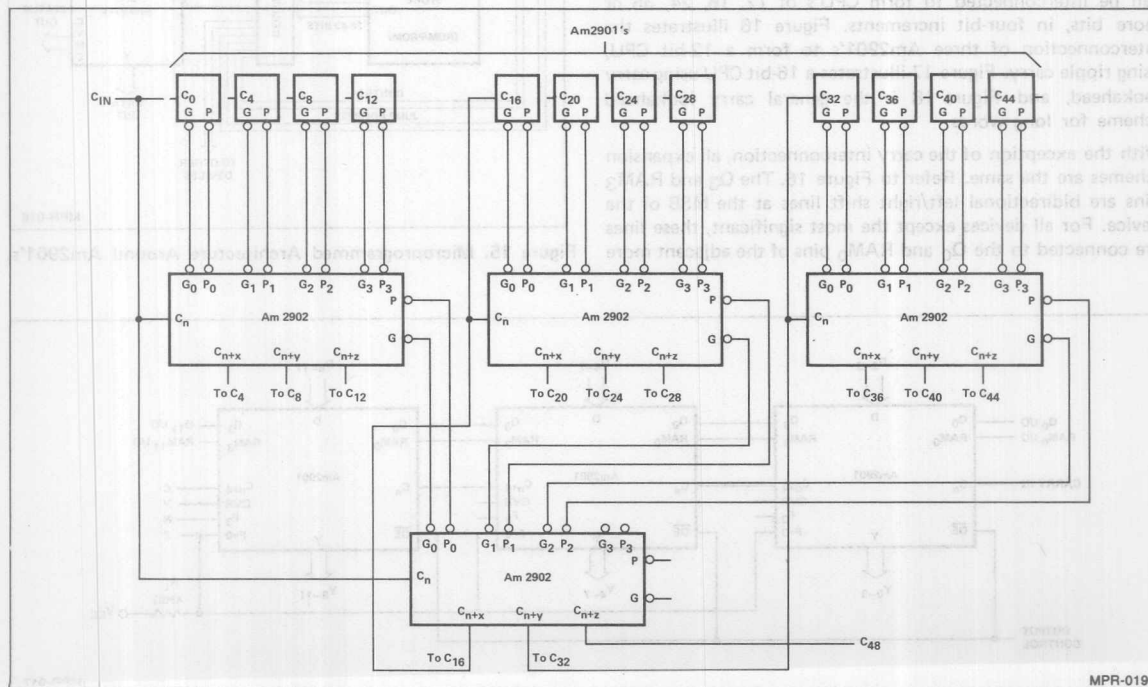


Figure 18. Carry Lookahead Scheme for 48-Bit CPU Using 12 Am2901s. The Carry-Out Flag ( $C_{48}$ ) Should be Taken From the Lower Am2902 Rather Than the Right-Most Am2901 for Higher Speed.



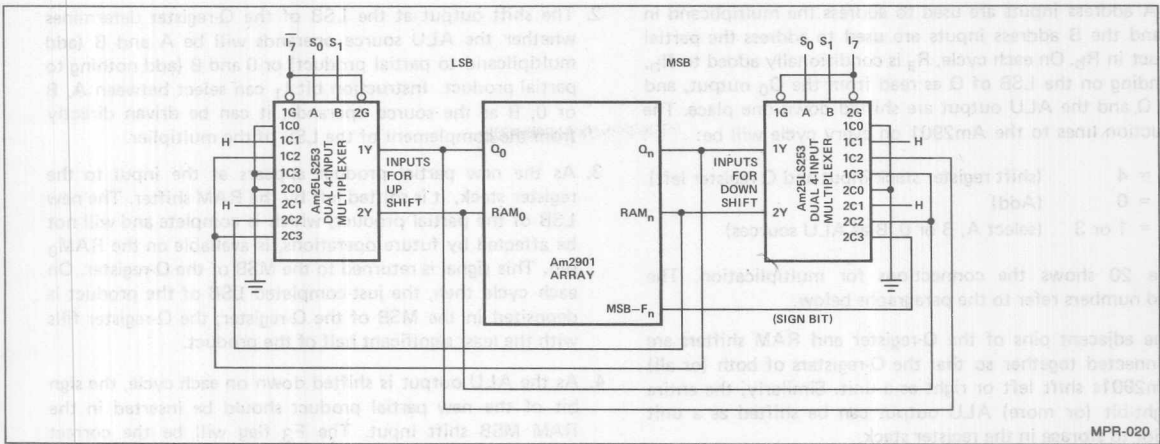


Figure 19. Three-State Multiplexers Used on Shift I/O Lines.

SHIFT I/O LINES AT THE END OF THE ARRAY

The Q-register and RAM left/right shift data transfers occur between devices over bidirectional lines. At the ends of the array, three-state multiplexers are used to select what the new inputs to the registers should be during shifting. The Am2904 includes these multiplexers in a single LSI chip. Figure 19 shows two Am25LS253 dual four-input multiplexers connected to provide four shift modes. Instruction bit  $I_7$  (from the Am2901) is used to select whether the left-shift multiplexer or the right-shift multiplexer is active. The four shift modes in this example are:

**Zero** A LOW is shifted into the MSB of the RAM on a down shift. If the Q-register is also shifted, then a LOW is deposited in the Q-register MSB. If the RAM or both registers are shifted up, LOWs are placed in the LSBs.

- One** Same as zero, but a HIGH level is deposited in the LSB or MSB.
- Rotate** A single precision rotate. The RAM MSB shifts into the LSB on a right shift and the LSB shifts into the MSB on a left shift. The Q-register, if shifted, will rotate in the same manner.
- Arithmetic** A double-length Arithmetic Shift if Q is also shifted. On an up shift a zero is loaded into the Q-register LSB and the Q-register MSB is loaded into the RAM LSB. On a down shift, the RAM LSB is loaded into the Q-register MSB and the ALU output MSB ( $F_n$ , the sign bit) is loaded into the RAM MSB. (This same bit will also be in the next less significant RAM bit.)

| Code  |       |       | Source of New Data |           |         |                           | Shift | Type       |
|-------|-------|-------|--------------------|-----------|---------|---------------------------|-------|------------|
| $I_7$ | $S_1$ | $S_0$ | $Q_0$              | $Q_n$     | $RAM_0$ | $RAM_n$                   |       |            |
| H     | L     | L     | 0                  | $Q_{n-1}$ | 0       | $F_{n-1}$                 | Up    | Zero       |
| H     | L     | H     | 1                  | $Q_{n-1}$ | 1       | $F_{n-1}$                 |       | One        |
| H     | H     | L     | $Q_n$              | $Q_{n-1}$ | $F_n$   | $F_{n-1}$                 |       | Rotate     |
| H     | H     | H     | 0                  | $Q_{n-1}$ | $Q_n$   | $F_{n-1}$                 |       | Arithmetic |
| L     | L     | L     | $Q_1$              | 0         | $F_1$   | 0                         | Down  | Zero       |
| L     | L     | H     | $Q_1$              | 1         | $F_1$   | 1                         |       | One        |
| L     | H     | L     | $Q_1$              | $Q_0$     | $F_1$   | $F_0$                     |       | Rotate     |
| L     | H     | H     | $Q_1$              | $F_0$     | $F_1$   | $RAM_n = RAM_{n-1} = F_n$ |       | Arithmetic |

HARDWARE MULTIPLICATION

Figure 20 illustrates the interconnections for a hardware multiplication using the Am2901. The system shown uses two devices for  $8 \times 8$  multiplication, but the expansion to more bits is simple — the significant connections are at the LSB and MSB only.

The basic technique used is the "add and shift" algorithm. One clock cycle is required for each bit of the multiplier. On each cycle, the LSB of the multiplier is examined; if it is a "1", then

the multiplicand is added to the partial product to generate a new partial product. The partial product is then shifted one place toward the LSB, and the multiplier is also shifted one place toward the LSB. The old LSB of the multiplier is discarded. The cycle is then repeated on the new LSB of the multiplier available at  $Q_0$ .

The multiplier is in the Am2901 Q-register. The multiplicand is in one of the registers in the register stack,  $R_a$ . The product will be developed in another of the registers in the stack,  $R_b$ .

The A address inputs are used to address the multiplicand in  $R_a$ , and the B address inputs are used to address the partial product in  $R_b$ . On each cycle,  $R_a$  is conditionally added to  $R_b$ , depending on the LSB of Q as read from the  $Q_0$  output, and both Q and the ALU output are shifted down one place. The instruction lines to the Am2901 on every cycle will be:

$I_{876} = 4$  (shift register stack input and Q register left)  
 $I_{543} = 0$  (Add)  
 $I_{210} = 1$  or 3 (select A, B or 0, B as ALU sources)

Figure 20 shows the connections for multiplication. The circled numbers refer to the paragraphs below.

1. The adjacent pins of the Q-register and RAM shifters are connected together so that the Q-registers of both (or all) Am2901s shift left or right as a unit. Similarly, the entire eight-bit (or more) ALU output can be shifted as a unit prior to storage in the register stack.

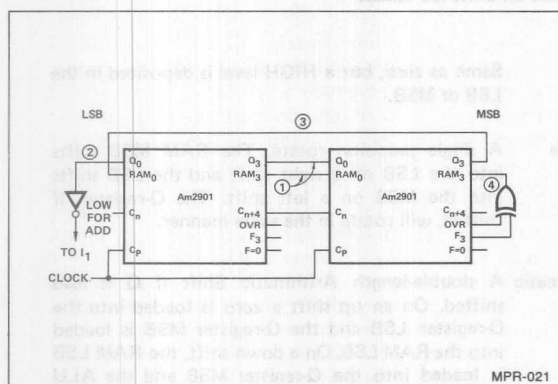


Figure 20. Interconnection for Dedicated Multiplication (8 by 8 Bit) (Corresponding A, B and I Connected Together).

2. The shift output at the LSB of the Q-register determines whether the ALU source operands will be A and B (add multiplicand to partial product) or 0 and B (add nothing to partial product). Instruction bit  $I_1$  can select between A, B or 0, B as the source operands; it can be driven directly from the complement of the LSB of the multiplier.
3. As the new partial product appears at the input to the register stack, it is shifted left by the RAM shifter. The new LSB of the partial product, which is complete and will not be affected by future operations, is available on the  $RAM_0$  pin. This signal is returned to the MSB of the Q-register. On each cycle then, the just-completed LSB of the product is deposited in the MSB of the Q-register; the Q-register fills with the least significant half of the product.
4. As the ALU output is shifted down on each cycle, the sign bit of the new partial product should be inserted in the RAM MSB shift input. The  $F_3$  flag will be the correct sign of the partial product unless overflow has occurred. If overflow occurs during an addition or subtraction, the OVR flag will go HIGH and  $F_3$  is not the sign of the result. The sign of the result must then be the complement of  $F_3$ . The correct sign bit to shift into the MSB of the partial product is therefore  $F_3 \oplus OVR$ ; that is,  $F_3$  if overflow has not occurred and  $\bar{F}_3$  if overflow has occurred. On the last cycle, when the MSB of the multiplier is examined, a conditional subtraction rather than addition should be performed, because the sign bit of the multiplier carries negative rather than positive arithmetic weight.

$$Y = -Y_i 2^i + Y_{i-1} 2^{i-1} + \dots + Y_0 2^0$$

This scheme will produce a correct two's complement product for all multiplicands and multipliers in two's complement notation.

Figure 21 is a table showing the input states of the Am2901 for each step of a signed, two's complement multiplication. The Am2904 LSI chip conveniently implements the required shift linkages and the EX-OR function for this algorithm.

| Initial Register States |              |                         |     | Am2901 Microcode           |   |           |           |                          |       |       |         |         |                |    |  | Final Register States |              |  |  |
|-------------------------|--------------|-------------------------|-----|----------------------------|---|-----------|-----------|--------------------------|-------|-------|---------|---------|----------------|----|--|-----------------------|--------------|--|--|
| R                       |              |                         |     | Program 2's Comp. Multiply |   |           |           |                          |       |       |         |         |                |    |  | R                     |              |  |  |
| 0                       | Multiplier   |                         |     | Date 8/5/75 By J. S.       |   |           |           |                          |       |       |         |         |                |    |  | 0                     | Multiplier   |  |  |
| 1                       | Multiplicand |                         |     |                            |   |           |           |                          |       |       |         |         |                |    |  | 1                     | Multiplicand |  |  |
| 2                       | X            |                         |     |                            |   |           |           |                          |       |       |         |         |                |    |  | 2                     | LSH Product  |  |  |
| 3                       | X            |                         |     |                            |   |           |           |                          |       |       |         |         |                |    |  | 3                     | MSH Product  |  |  |
| S, F →                  |              |                         |     | Pin States (Octal)         |   |           |           |                          |       |       |         |         |                |    |  | Jump                  |              |  |  |
|                         |              |                         |     | A                          | B | $I_{876}$ | $I_{543}$ | $I_{210}$                | $C_n$ | $Q_0$ | $Q_3$   | $RAM_0$ | $RAM_3$        | To |  | If                    |              |  |  |
| O V A                   | Q            | Move Multiplier to Q    | —   | 0                          | X | 0         | 3         | 4                        | X     | X     | X       | X       | X              |    |  |                       |              |  |  |
| O ∧ B                   | B            | Clear $R_3$             | —   | X                          | 3 | 2         | 4         | 3                        | X     | X     | X       | X       | X              |    |  |                       |              |  |  |
| (O+B)/2<br>(A+B)/2      | B            | Cond. Add & Shift       | n-1 | 1                          | 3 | 4         | 0         | 1 or 3<br>$I_1 = Q_0 LO$ | 0     | —     | $RAM_0$ | —       | $F_3 \vee OVR$ |    |  |                       |              |  |  |
| (B-O)/2<br>(B-A)/2      | B            | Cond. Subt. & Shift     | —   | 1                          | 3 | 4         | 1         | 1 or 3<br>$I_1 = Q_0 LO$ | 1     | —     | $RAM_0$ | —       | $F_3 \vee OVR$ |    |  |                       |              |  |  |
| O V Q                   | B            | Move LSH Prod. to $R_2$ | —   | X                          | 2 | 2         | 3         | 2                        | X     | X     | X       | X       | X              |    |  |                       |              |  |  |

X = Don't Care    S = Source    F = Function    D = Destination

Figure 21.

## Hardware Division

Division, unlike multiplication, is much more difficult to realize. One of these difficulties can be easily understood by visualizing a 2n-bit Dividend (X) and an n-bit Divisor (Y). The Quotient (Q) can range from 1 bit (when  $X \leq Y$ ) to 2n bits (when  $Y = 1$ ), discarding the attempt to divide by 0. In most of the divide functions, the Remainder (R) is as important to find as is the Quotient — there is no equivalent to it in multiplication. Division becomes even more complicated when negative numbers are represented in the 2's complement notation. In the "everyday" decimal system, using Sign-and-Magnitude notation, dealing with negative numbers is relatively easy: The sign of the quotient is determined first and then a normal division is performed. Note that in this "normal" division we first "guess" the first digit of the quotient by comparing the most significant part of the dividend to the divisor. Then verify our guess by a multiplication (no "direct" division method is known), and continue to do so for all of the other digits, shifting the divisor to the right one place at a time.

The most straightforward division scheme (for unsigned numbers) is Subsequent Subtraction. The algorithm is as follows: Subtract divisor from dividend and increment a counter (initially reset to zero). Continue to do so as long as the Remainder is positive. When the Remainder becomes negative, cancel the last step; i.e., add back divisor and decrement counter. The counter will contain the Quotient and the Remainder will be correct. The main drawback of this scheme is, of course, the great number of arithmetic operations needed. Again, when dealing with signed numbers, the subtraction should be substituted by addition and vice versa.

A more rapid division can be realized by calculating the Quotient digits instead of counting them. In this algorithm, the divisor is first subtracted from the most significant part of the dividend. If the remainder is positive, the quotient digit is "1", otherwise the subtraction is cancelled (by adding the

divisor to the remainder) and the quotient digit will be "0". Now shift the remainder one place to the right (much like you do in a "paper and pencil" division) and repeat until all the quotient digits have been calculated. This algorithm is called "Restoring Division". When signed numbers are involved, inversion of the operations and the quotient digits will be necessary and correction should be performed in some cases. Some time is wasted in the Restoring Division because for every "0" digit in the quotient, two arithmetic operations are needed. This can be saved in the "Non-Restoring Division".

The basis of Non-Restoring Division is the same as in Restoring Division. Consider first unsigned (positive) numbers only. At the beginning, the divisor is subtracted from the most significant part of the dividend. If the result (first remainder) is positive (or zero), the first quotient digit is "1". Otherwise, the quotient digit is "0", but do not restore! Shift divisor one place to the right (or remainder to the left) and add if last quotient digit was "0"; otherwise subtract. Determine quotient digit as before and continue until all quotient digits have been computed. The remainder will be correct if it is non-negative, otherwise correction is needed by a restoring operation (on the remainder only). Extreme care should be taken of the number of bits and the value of the divisor. Assuming the divisor has n bits and the dividend as 2n bits, the above process develops n+1 bits of the quotient. This will not be sufficient if the MSB of the divisor is "0" (which means that the divisor is a small number and more digits are needed in the quotient). Although this condition can be easily detected as overflow will occur in the first subtraction, it can be avoided by aligning the first "1" of the divisor to the MSB of the dividend (by shifting the divisor left until all leading zeros are discarded) before performing the first subtraction. Ample space should be provided for the additional bits of the quotient. Note that leading zeros in the dividend do not disturb the normal operation. The flow chart for unsigned non-restoring division is shown in Figure 22.

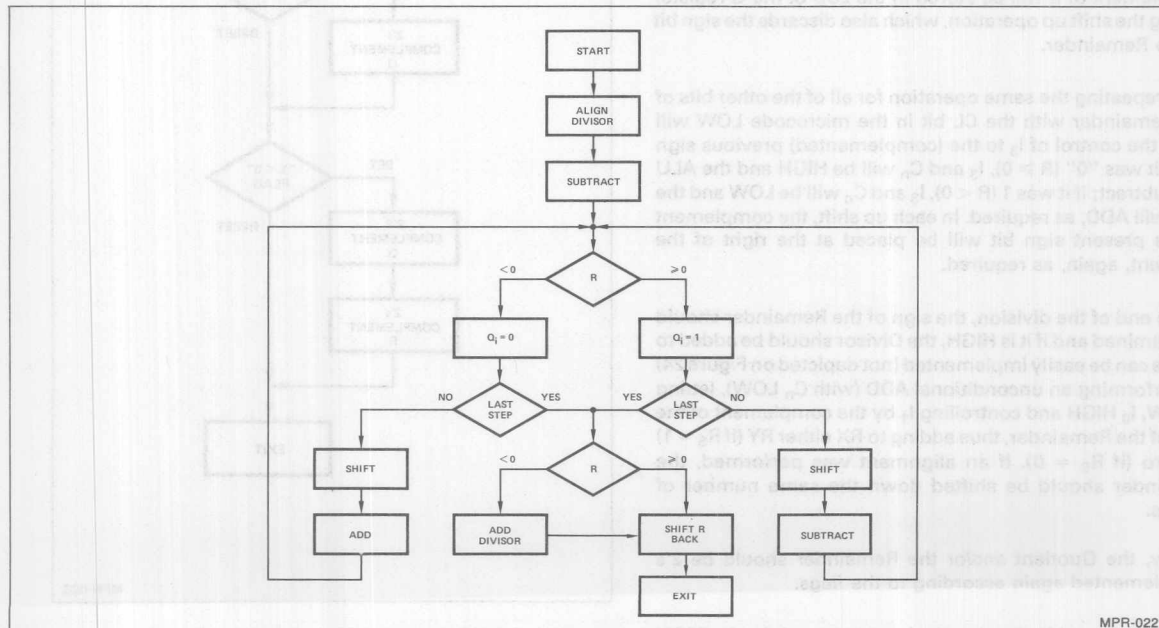


Figure 22. Flowchart for Non-Restoring Division (Unsigned Numbers).

The unsigned division scheme can be applied to signed positive numbers without any change. When negative numbers are encountered, however, changes in the algorithm are necessary. The straightforward method of signed division seems to be "Division in the first quadrant." In that scheme, negative numbers are 2's complemented to obtain positive numbers, remembering the changes done. The division is performed on positive numbers, and finally again 2's complementing occurs wherever necessary. Figure 23 is the flowchart for this algorithm.

Figure 24 is the Interconnection Diagram for both the alignment procedure and the Division Algorithm. It is assumed that the Dividend is in Register  $R_X$  (it will be lost during the division and replaced by the Remainder), the Divisor is in Register  $R_Y$ . The Quotient will be in the Q register, which should be cleared beforehand.

After checking the signs of the Dividend and Divisor, setting the flags and negating (using 23 or 24 octal as  $I_5$  through  $I_0$  ALU control bits) when necessary, the Divisor should be aligned. This can be done by ORing  $R_X$  with 0 ( $I_5-0 = 33$  octal). The most significant bit is deposited in the Status Register, and can be shifted out by setting  $I_8 = I_6 = \text{HIGH}$  and  $I_7$  to the Exclusive NOR of the previous and present MSB of the Divisor. If these are both "0",  $I_7$  will be HIGH, and an up shift will occur, filling in trailing zeros. When the checked bits are different,  $I_7$  will go LOW, causing a down shift. At the same time the Y output of the Status Register is enabled the leftmost "0" (the sign bit) will be restored.

The first step in the Division routine is a subtract, then shift the  $R_X$  and Q registers up.  $I_{876}$  will be 6 in octal while  $I_{210} = 1$  in octal and  $I_5 = I_4 = \text{LOW}$ . Pulling the CL bit in the microcode to HIGH, both  $I_3$  and  $C_n$  will be HIGH and the ALU is performing a 2's complement subtract. The sign of the Remainder will be latched in the Status Register and the complement of it will be stored in the LSB of the Q register during the shift up operation, which also discards the sign bit of the Remainder.

Now repeating the same operation for all of the other bits of the Remainder with the CL bit in the microcode LOW will leave the control of  $I_3$  to the (complemented) previous sign bit. If it was "0" ( $R \geq 0$ ),  $I_3$  and  $C_n$  will be HIGH and the ALU will subtract; if it was 1 ( $R < 0$ ),  $I_3$  and  $C_n$  will be LOW and the ALU will ADD, as required. In each up shift, the complement of the present sign bit will be placed at the right of the Quotient, again, as required.

At the end of the division, the sign of the Remainder should be examined and if it is HIGH, the Divisor should be added to it. This can be easily implemented (not depicted on Figure 24) by performing an unconditional ADD (with  $C_n$  LOW), letting  $I_2$  LOW,  $I_0$  HIGH and controlling  $I_1$  by the complement of the sign of the Remainder, thus adding to  $R_X$  either  $R_Y$  (if  $R_S = 1$ ) or zero (if  $R_S = 0$ ). If an alignment was performed, the remainder should be shifted down the same number of places.

Finally, the Quotient and/or the Remainder should be 2's complemented again according to the flags.

Figure 25 is a table showing the input states of the Am2901s for each phase of the Alignment and Division.

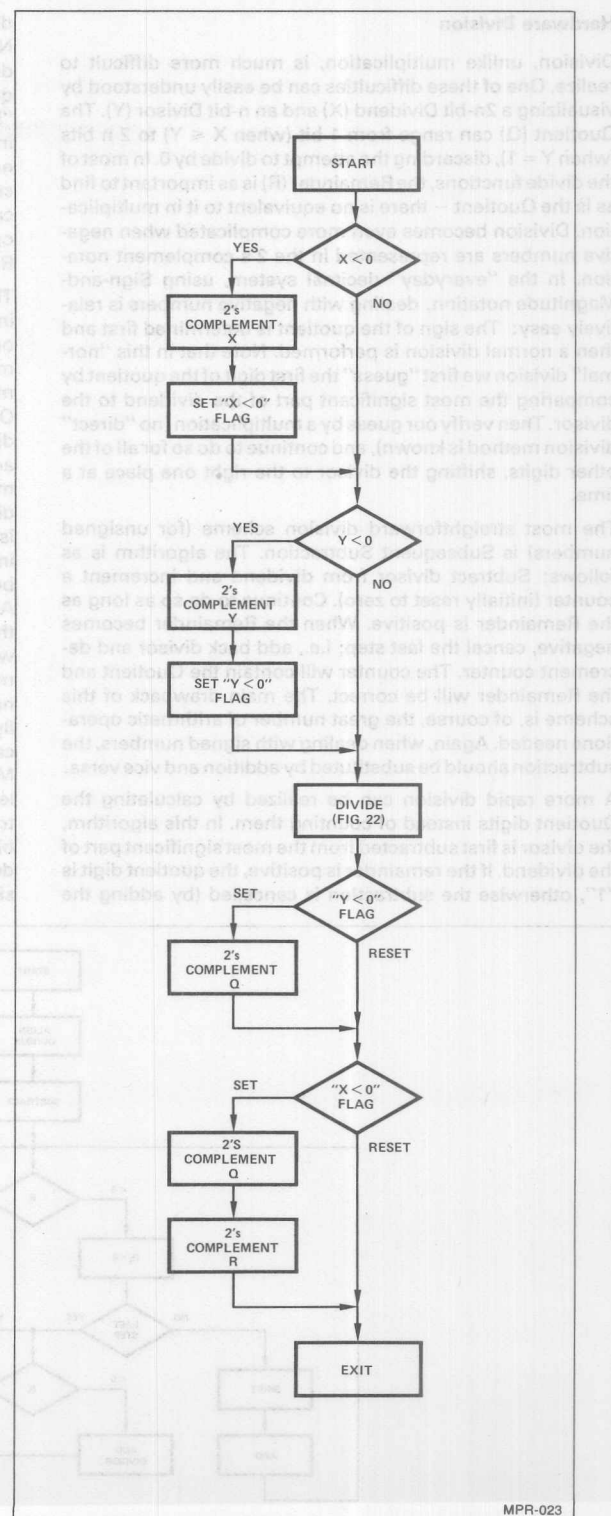
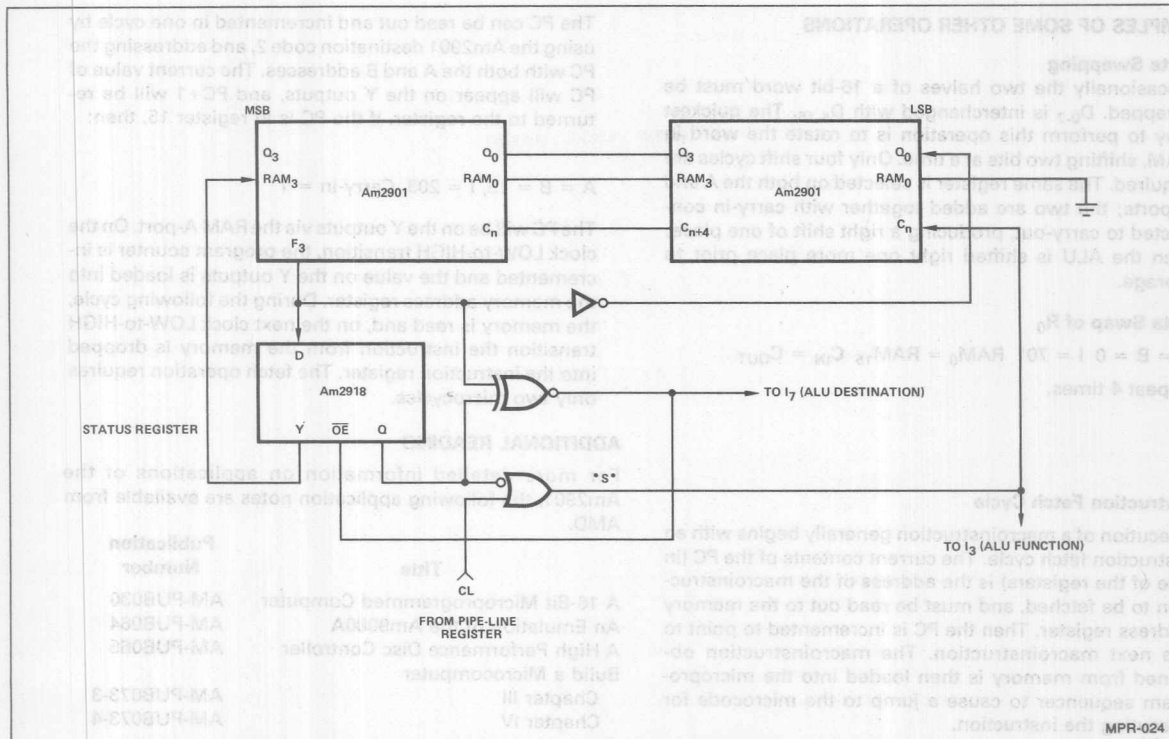


Figure 23. Flowchart for First Quadrant Division with Signed Numbers.





**Figure 24. Interconnections for Dedicated Division.**

Initial Register Status

Am2901 Microcode

Final Register Status

R

|   |           |
|---|-----------|
| 0 | Dividend  |
| 1 | Divisor   |
| Q | (Cleared) |

Program: 2's Complement Division  
Date: 9/24/76 By: M.S.

R

|   |           |
|---|-----------|
| 0 | Remainder |
| 1 | Divisor   |
| Q | Quotient  |

| S, F     | D | Description               | CL | Repeat | Pin Status (Octal) |   |                  |                  |                  |                |                  |                |                  |                  | Jump |    |
|----------|---|---------------------------|----|--------|--------------------|---|------------------|------------------|------------------|----------------|------------------|----------------|------------------|------------------|------|----|
|          |   |                           |    |        | A                  | B | I <sub>876</sub> | I <sub>543</sub> | I <sub>210</sub> | C <sub>n</sub> | Q <sub>0</sub>   | Q <sub>3</sub> | RAM <sub>0</sub> | RAM <sub>3</sub> | to   | if |
| OVB      | B | Align Divisor             | X  | k      | X                  | 1 | 5/7              | 3                | 3                | X              | X                | X              | 0                | X or Sign        |      |    |
| (B-A) *2 | B | First Subtract & Shift    | 1  | —      | 1                  | 0 | 6                | 1                | 1                | 1              | $\overline{F}_3$ | X              | 0                | X                |      |    |
| (B±A) *2 | B | Loop Subtract/Add & Shift | 0  | k      | 1                  | 0 | 6                | 1/0              | 1                | 1/0            | $\overline{F}_3$ | X              | 0                | X                |      |    |
| B+A or   | B | Correct Remainder         | X  | —      | 1                  | 0 | 3                | 0                | 1/3              | 0              | X                | X              | X                | X                |      |    |
| B+0      | B | Shift Remainder           | 1  | k      | X                  | 1 | 5                | 1                | 3                | 1              | X                | X              | X                | Sign             |      |    |

k = Number of leading zeros of the Divisor



# Am2901C

## Four-Bit Bipolar Microprocessor Slice

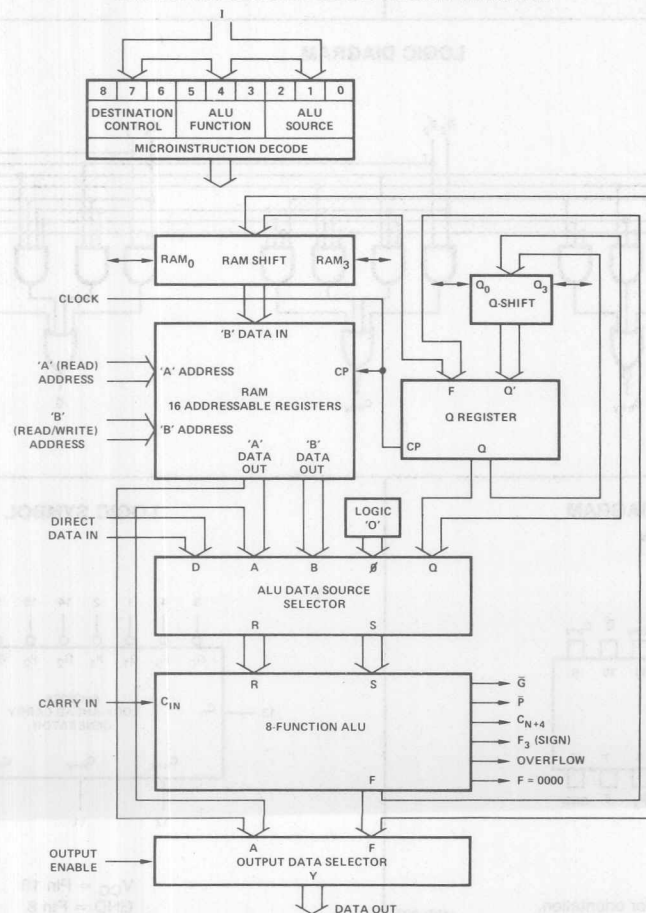
### ADVANCED INFORMATION

#### DISTINCTIVE CHARACTERISTICS

- **Third generation of Am2901 four-bit slice**  
Internal ECL circuitry and state-of-the-art process technology combined to provide fastest version of popular Am2901.
- **Plug-in replacement for Am2901, Am2901A, Am2901B**  
The Am2901C is a pin-for-pin replacement for earlier versions of the device. Only the switching speeds are changed.
- **Improved speed**  
25-30% speed improvement on the critical paths versus the Am2901B

2

#### MICROPROCESSOR SLICE BLOCK DIAGRAM



MPR-044

# Am2902A

## High-Speed Look-Ahead Carry Generator

### DISTINCTIVE CHARACTERISTICS

- Provides look-ahead carries across a group of four Am2901 microprocessor ALU's
- Capability of multi-level look-ahead for high-speed arithmetic operation over large word lengths
- Typical carry propagation delay of 4.5 ns
- 100% reliability assurance testing in compliance with MIL-STD-883

### FUNCTIONAL DESCRIPTION

The Am2902A is a high-speed, look-ahead carry generator which accepts up to four pairs of carry propagate and carry generate signals and a carry input and provides anticipated carries across four groups of binary ALU's. The device also has carry propagate and carry generate outputs which may be used for further levels of look-ahead.

The Am2902A is generally used with the Am2901 bipolar microprocessor unit to provide look-ahead over word lengths of more than four bits. The look-ahead carry generator can be used with binary ALU's in an active LOW or active HIGH input operand mode by reinterpreting the carry functions. The connections to and from the ALU to the look-ahead carry generator are identical in both cases.

The logic equations provided at the outputs are:

$$C_{n+x} = G_0 + P_0 C_n$$

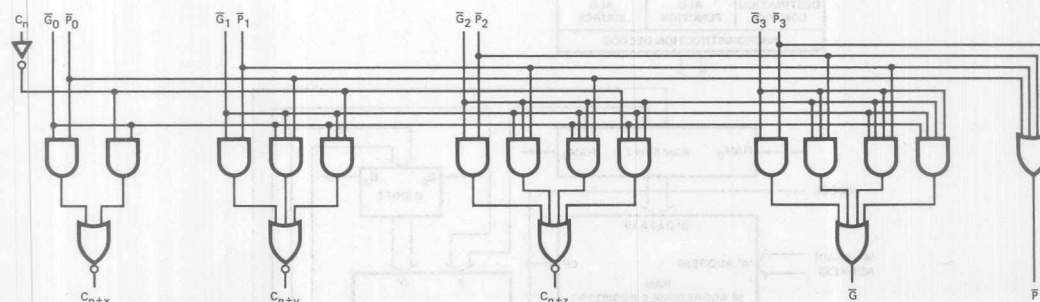
$$C_{n+y} = G_1 + P_1 G_0 + P_1 P_0 C_n$$

$$C_{n+z} = G_2 + P_2 G_1 + P_2 P_1 G_0 + P_2 P_1 P_0 C_n$$

$$G = G_3 + P_3 G_2 + P_3 P_2 G_1 + P_3 P_2 P_1 G_0$$

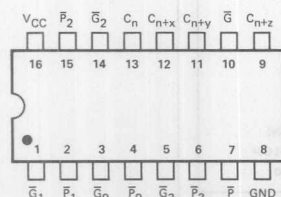
$$P = P_3 P_2 P_1 P_0$$

### LOGIC DIAGRAM



MPR-026

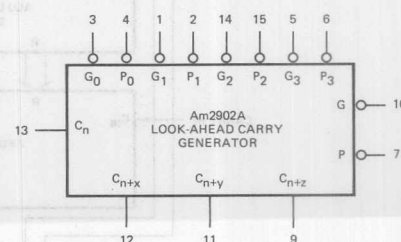
### CONNECTION DIAGRAM Top View



Note: Pin 1 is marked for orientation.

MPR-027

### LOGIC SYMBOL



$V_{CC}$  = Pin 16  
GND = Pin 8

MPR-025



**MAXIMUM RATINGS** (Above which the useful life may be impaired)

|   |                                |
|---|--------------------------------|
| Storage Temperature                                 | −65°C to +150°C                |
| Temperature (Ambient) Under Bias                    | −55°C to +125°C                |
| Supply Voltage to Ground Potential                  | −0.5V to +7.0V                 |
| DC Voltage Applied to Outputs for HIGH Output State | −0.5V to +V <sub>CC</sub> max. |
| DC Input Voltage                                    | −0.5V to +5.5V                 |
| DC Output Current, Into Outputs                     | 30 mA                          |
| DC Input Current                                    | −30 mA to +5.0 mA              |

**ELECTRICAL CHARACTERISTICS OVER OPERATING TEMPERATURE RANGE** (Unless Otherwise Noted)

| Am2902AXC       | T <sub>A</sub> = 0°C to +70°C    | V <sub>CC</sub> = 5.0V ±5% (COM'L)   | MIN. = 4.75V                      | MAX. = 5.25V     |      |       |  |
|-----------------|----------------------------------|--|-----------------------------------|------------------|------|-------|--|
| Am2902AXM       | T <sub>A</sub> = −55°C to +125°C | V <sub>CC</sub> = 5.0V ±10% (MIL)  | MIN. = 4.50V                      | MAX. = 5.50V     |      |       |  |
| Parameters      | Description                      | Test Conditions (Note 1)   | Min.                              | Typ.<br>(Note 2) | Max. | Units |  |
| V <sub>OH</sub> | Output HIGH Voltage              | V <sub>CC</sub> = MIN., I <sub>OH</sub> = −1mA<br>V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub> | MIL<br>2.7                        | 3.4<br>3.4       |      | Volts |  |
| V <sub>OL</sub> | Output LOW Voltage               | V <sub>CC</sub> = MIN., I <sub>OL</sub> = 20mA<br>V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub> |                                   |                  | 0.5  | Volts |  |
| V <sub>IH</sub> | Input HIGH Level                 | Guaranteed input logical HIGH voltage for all inputs   | 2.0                               |                  |      | Volts |  |
| V <sub>IL</sub> | Input LOW Level                  | Guaranteed input logical LOW voltage for all inputs  |                                   |                  | 0.8  | Volts |  |
| V <sub>I</sub>  | Input Clamp Voltage              | V <sub>CC</sub> = MIN., I <sub>IN</sub> = −18mA  |                                   |                  | −1.2 | Volts |  |
| I <sub>IL</sub> | Input LOW Current                | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 0.5V   | C <sub>n</sub>                    |                  | −2   | mA    |  |
|                 |                                  |  | $\bar{P}_3$                       |                  | −4   |       |  |
|                 |                                  |  | $\bar{P}_2$                       |                  | −6   |       |  |
|                 |                                  |  | $\bar{P}_0, \bar{P}_1, \bar{G}_3$ |                  | −8   |       |  |
|                 |                                  |  | $\bar{G}_0, \bar{G}_2$            |                  | −14  |       |  |
|                 |                                  |  | $\bar{G}_1$                       |                  | −16  |       |  |
| I <sub>IH</sub> | Input HIGH Current               | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 2.7V   | C <sub>n</sub>                    |                  | 50   | μA    |  |
|                 |                                  |  | $\bar{P}_3$                       |                  | 100  |       |  |
|                 |                                  |  | $\bar{P}_2$                       |                  | 150  |       |  |
|                 |                                  |  | $\bar{P}_0, \bar{P}_1, \bar{G}_3$ |                  | 200  |       |  |
|                 |                                  |  | $\bar{G}_0, \bar{G}_2$            |                  | 350  |       |  |
|                 |                                  |  | $\bar{G}_1$                       |                  | 400  |       |  |
| I <sub>I</sub>  | Input HIGH Current               | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 5.5V   |                                   |                  | 1.0  | mA    |  |
| I <sub>SC</sub> | Output Short Circuit<br>(Note 3) | V <sub>CC</sub> = MAX., V <sub>OUT</sub> = 0.0V  | −40                               |                  | −100 | mA    |  |
| I <sub>CC</sub> | Power Supply Current             | V <sub>CC</sub> = MAX.<br>All Outputs LOW  | MIL                               | 69               | 99   | mA    |  |
|                 |                                  |  | COM'L                             | 69               | 109  |       |  |
|                 |                                  | V <sub>CC</sub> = MAX.<br>All Outputs HIGH   | MIL                               | 35               |      | mA    |  |
|                 |                                  |  | COM'L                             | 35               |      |       |  |

- Notes: 1. For conditions shown as MIN. or MAX., use the appropriate value specified under Electrical Characteristics for the applicable device type.  
 2. Typical limits are at V<sub>CC</sub> = 5.0V, 25°C ambient and maximum loading.  
 3. Not more than one output should be shorted at a time. Duration of the short circuit test should not exceed one second.

**SWITCHING CHARACTERISTICS**(T<sub>A</sub> = +25°C, V<sub>CC</sub> = 5.0V)

| Parameters       | Description   | Min. | Typ. | Max. | Units | Test Conditions                                |
|------------------|---|------|------|------|-------|--|
| t <sub>PLH</sub> | C <sub>n</sub> to C <sub>n+x</sub> , C <sub>n+y</sub> , or C <sub>n+z</sub>                       |      | 6.5  | 10   | ns    | C <sub>L</sub> = 15pF<br>R <sub>L</sub> = 280Ω |
| t <sub>PHL</sub> |   |      | 7    | 10.5 |       |  |
| t <sub>PLH</sub> | $\overline{P}_i$ or $\overline{G}_i$ to C <sub>n+x</sub> , C <sub>n+y</sub> , or C <sub>n+z</sub> |      | 4.5  | 7    | ns    |  |
| t <sub>PHL</sub> |   |      | 4.5  | 7    |       |  |
| t <sub>PLH</sub> | $\overline{P}_i$ or $\overline{G}_i$ to $\overline{G}$  |      | 5    | 7.5  | ns    |  |
| t <sub>PHL</sub> |   |      | 7    | 10.5 |       |  |
| t <sub>PLH</sub> | $\overline{P}_i$ to $\overline{P}$  |      | 4.5  | 6.5  | ns    |  |
| t <sub>PHL</sub> |   |      | 6.5  | 10   |       |  |

### SWITCHING CHARACTERISTICS OVER OPERATING RANGE\*

| Parameters       |   | Description | T <sub>A</sub> = 0°C to +70°C<br>V <sub>CC</sub> = 5.0V ±5% |      | T <sub>A</sub> = −55°C to +125°C<br>V <sub>CC</sub> = 5.0V ±10% |      | Units  | Test Conditions |
|------------------|---|-------------|---|------|---|------|--|-----------------|
|                  |   |             | Min.  | Max. | Min.  | Max. |  |                 |
| t <sub>PLH</sub> | C <sub>n</sub> to C <sub>n+x</sub> , C <sub>n+y</sub> , or C <sub>n+z</sub>                       |             | 13  |      | 15  | ns   | C <sub>L</sub> = 50pF<br>R <sub>L</sub> = 280Ω |                 |
| t <sub>PHL</sub> |   |             | 14  |      | 16.5  | ns   |  |                 |
| t <sub>PLH</sub> | $\overline{P}_i$ or $\overline{G}_i$ to C <sub>n+x</sub> , C <sub>n+y</sub> , or C <sub>n+z</sub> |             | 8   |      | 9.5   | ns   |  |                 |
| t <sub>PHL</sub> |   |             | 9   |      | 11.5  | ns   |  |                 |
| t <sub>PLH</sub> | $\overline{P}_i$ or $\overline{G}_i$ to $\overline{G}$  |             | 12  |      | 16.5  | ns   |  |                 |
| t <sub>PHL</sub> |   |             | 12  |      | 13.5  | ns   |  |                 |
| t <sub>PLH</sub> | $\overline{P}_i$ to $\overline{P}$  |             | 9.5   |      | 11.5  | ns   |  |                 |
| t <sub>PHL</sub> |   |             | 11  |      | 12  | ns   |  |                 |

\*AC performance over the operating temperature range is guaranteed by testing defined in Group A, Subgroup 9.

## DEFINITION OF FUNCTIONAL TERMS

**C<sub>n</sub>** Carry-in. The carry-in input to the look-ahead generator. Also the carry-in input to the nth Am2901A microprocessor ALU input.

**C<sub>n+j</sub>** Carry-out. ( $j = x, y, z$ ). The carry-out output to be used at the carry-in inputs of the  $n+1$ ,  $n+2$  and  $n+3$  microprocessor ALU slices.

**G<sub>i</sub>, P<sub>i</sub>** Generate and propagate inputs respectively ( $i = 0, 1, 2, 3$ ). The carry generate and carry propagate inputs from the  $n$ ,  $n+1$ ,  $n+2$  and  $n+3$  microprocessor ALU slices.

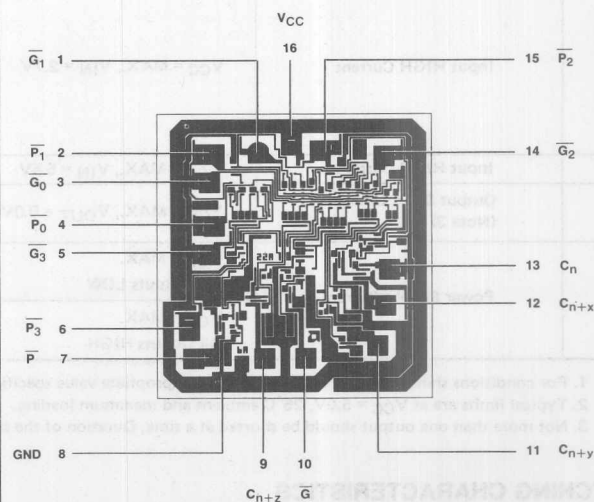
**G, P** Generate and propagate outputs respectively. The carry generate and carry propagate outputs that can be used with the next higher level of carry look-ahead if used.

### TRUTH TABLE

[illegible]

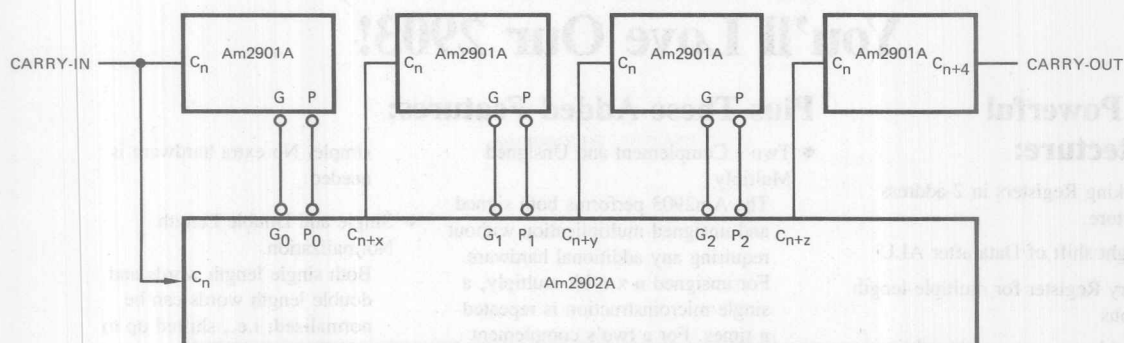
H = HIGH Voltage Level  
L = LOW Voltage Level  
X = Don't Care

### Metallization and Pad Layout



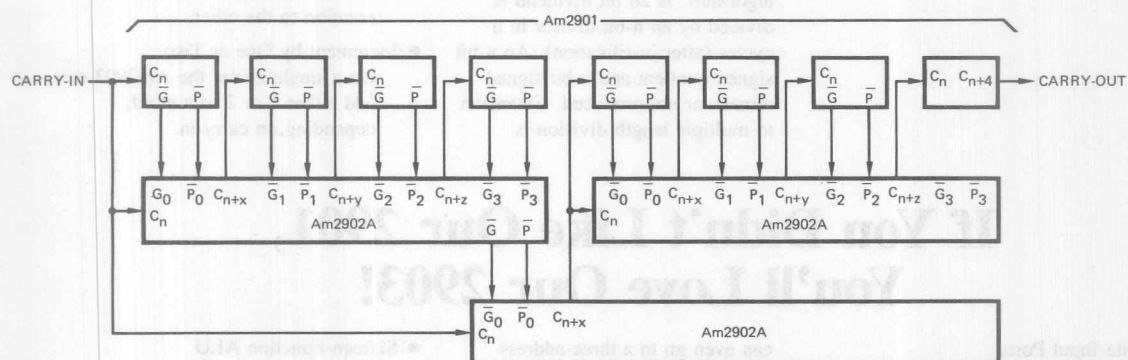
DIE SIZE 0.062" X 0.067"

## APPLICATIONS



### 16-BIT CARRY LOOK-AHEAD CONNECTION.

MPR-028



### 32-BIT ALU, THREE LEVEL CARRY LOOK-AHEAD.

MPR-029

## ORDERING INFORMATION

Order the part number according to the table below to obtain the desired package, temperature range, and screening level.

| Order Number | Package Type<br>(Note 1) | Operating Range<br>(Note 2) | Screening Level<br>(Note 3)                          |
|--------------|--------------------------|-----------------------------|--|
| AM2902APC    | P-16                     | C                           | C-1  |
| AM2902ADC    | D-16                     | C                           | C-1  |
| AM2902ADC-B  | D-16                     | C                           | B-1  |
| AM2902ADM    | D-16                     | M                           | C-3  |
| AM2902ADM-B  | D-16                     | M                           | B-3  |
| AM2902AFM    | F-16                     | M                           | C-3  |
| AM2902AFM-B  | F-16                     | M                           | B-3  |
| Am2902AXC    | Dice                     | C                           | Visual inspection<br>to MIL-STD-883<br>Method 2010B. |
| Am2902AXM    | Dice                     | M                           |  |

Notes: 1. P = Molded DIP, D = Hermetic DIP, F = Flat Pak. Number following letter is number of leads. See Appendix B for detailed outline. Where Appendix B contains several dash numbers, any of the variations of the package may be used unless otherwise specified.

2. C = 0°C to +70°C,  $V_{CC} = 4.75V$  to  $5.25V$ , M = -55°C to +125°C,  $V_{CC} = 4.50V$  to  $5.50V$ .

3. See Appendix A for details of screening. Levels C-1 and C-3 conform to MIL-STD-883, Class C. Level B-3 conforms to MIL-STD-883, Class B.

## If You Liked Our 2901, You'll Love Our 2903!

### Same Powerful Architecture:

- 16 Working Registers in 2-address architecture
- Left-Right shift of Data after ALU
- Auxiliary Register for multiple-length operations
- Expandable to any word length in multiples of four bits
- Carry, Overflow, Zero, and Negative Status Flags

### Plus These Added Features:

- Two's Complement and Unsigned Multiply  
The Am2903 performs both signed and unsigned multiplication without requiring any additional hardware. For unsigned  $n \times n$ -bit multiply, a single microinstruction is repeated  $n$  times. For a two's complement multiply, a single microinstruction is executed  $n-1$  times, and a second microinstruction is executed once. Both kinds of multiplies produce  $2n$  bit products.
- Two's Complement Divide  
The Am2903 performs a signed division using a non-restoring algorithm. A  $2n$  bit dividend is divided by an  $n$ -bit divisor in  $n$  cycles (after justification). An  $n$ -bit signed quotient and  $n$ -bit signed remainder are produced. Extension to multiple length division is simple. No extra hardware is needed.
- Single and Double Length Normalization  
Both single length words and double length words can be normalized; i.e., shifted up to remove leading zeros or ones. During the normalize instructions, the Am2903 provides special flags signaling the completion of normalization.
- Conversion Between Sign-Magnitude and Two's Complement Notations  
On a single cycle, the Am2903 will switch a word from one notation to the other.
- Increment by One or Two  
On a single cycle, the Am2903 can add either 1 or 2 to a word, depending on carry-in.

## If You Didn't Like Our 2901, You'll Love Our 2903!

- Two Data Input Ports  
The Am2903 can operate between any two internal registers, any internal register and an external data bus, or two external data buses.
- Expandable Register File  
The Am2903 hooks directly onto the Am2901 to provide *any number* of working registers, without losing the two-address architecture. You can even go to a three-address system, where on one cycle you operate on two registers and place the result in a third.
- Arithmetic and Logical Shifts  
Arithmetic shifts hold the MSB (sign bit) in place and shift the rest of the word *around* the MSB. Logical shifts shift all the bits in the word. The 2903 provides both types of shift.
- Sixteen-Function ALU  
Provides 9 Logic Functions and 7 Arithmetic Functions, twice as many functions as the 2901.
- Parity Generated Internally  
A Parity Generator operates on the ALU output and is cascaded between devices, so that a single pin contains parity across the entire ALU output.

## And If You Don't Quite Like Our 2903, You'll Definitely Love Our Am29203!

- BCD Arithmetic  
The Am29203 includes special functions for BCD add and subtract, as well as conversion between binary and BCD notations.
- A Byte Better  
The Am29203 is designed to efficiently handle byte operations with a minimum of external logic.
- Both Data Lines Bidirectional
- Decrement by 1 or 2 Instruction
- RAM is enabled only if instruction execution is enabled.



# Am2903 • Am29203

The Superslice®

## DISTINCTIVE CHARACTERISTICS

- **Expandable Register File** – Like the Am2901, the Am2903/29203 contains 16 internal working registers arranged in a two-address architecture. But the Am2903/29203 includes the necessary "hooks" to expand the register file externally to any number of registers.
- **Built-in Multiplication Logic** – Performing multiplication with the Am2901A requires a few external gates – these gates are contained on-chip in the Am2903/29203. Three special instructions are used for unsigned multiplication, two's complement multiplication and the last cycle of a two's complement multiplication.
- **Built-in Division Logic** – The Am2903/29203 contains all logic and interconnects for execution of a non-restoring, multiple-length division with correction of the quotient.
- **Built-in Normalization Logic** – The Am2903/29203 can simultaneously shift the Q Register and count in a working register. Thus, the mantissa and exponent of a floating-point number can be developed using a single microcycle per shift. Status flags indicate when the operation is complete.
- **Built-in Parity Generation Circuitry** – The Am2903/29203 can supply parity across the entire ALU output for use in error detection.
- **Built-in Sign Extension Circuitry** – To facilitate operation on different length two's complement numbers, the Am2903/29203 provides the capability to extend the sign at any slice boundary.
- **BCD Arithmetic (Am29203 only)** – Automatic BCD add and subtract and conversion between binary and BCD.
- **Improved Byte Handling (Am29203 only)** – Zero detection and register writing can be performed on a single byte rather than the whole word.
- **Two Bidirectional Data Lines (Am29203 only)** –

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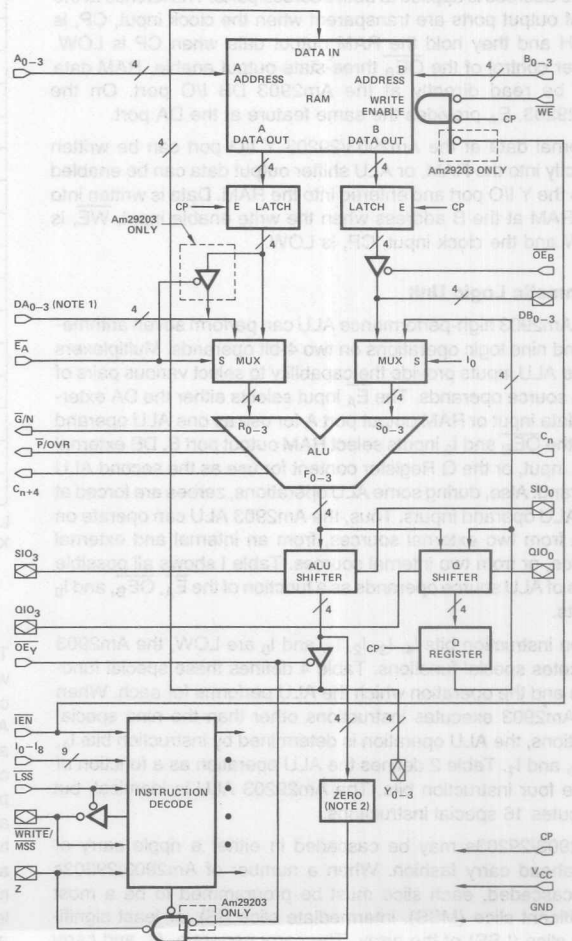
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## GENERAL DESCRIPTION

The Am2903 is a four-bit expandable bipolar microprocessor slice. The Am2903 performs all functions performed by the industry standard Am2901 and, in addition, provides a number of significant enhancements that are especially useful in arithmetic-oriented processors. Infinitely expandable memory and three-port, three-address architecture are provided by the Am2903. In addition to its complete arithmetic and logic instruction set, the Am2903 provides a special set of instructions which facilitate the implementation of multiplication, division, normalization, and other previously time-consuming operations. The Am29203 is a similar device, but has additional I/O capability, more special instructions and will be at least 30% faster.

2

## BLOCK DIAGRAM



Notes: 1. DA<sub>0-3</sub> is input only on Am2903, but is I/O port on Am29203.  
2. On Am2903, zero logic is connected to Y, after the OE<sub>Y</sub> buffer.

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processor since designed for use in microcomputers, peripheral controllers, microprogrammable machines, and numerous other applications. The microinstruction flexibility of the Am2903/29203 allows the efficient emulation of almost any digital computing machine. The nine-bit microinstruction selects the ALU sources, function and destination. The Am2903/29203 is cascadable with full lookahead or ripple carry, has 3-state outputs, and provides various ALU status flag outputs. Advanced Low-Power Schottky processing is used to fabricate this 48-pin LSI circuit.

All data paths within the device are four bits wide. As shown in the block diagram, the device consists of a 16-word by 4-bit, two-port RAM with latches on both output ports, a high-performance ALU and shifter, a multi-purpose Q Register with shifter input, and a nine-bit instruction decoder.

### Two-Port RAM

Any two RAM words addressed at the A and B address ports can be read simultaneously at the respective RAM A and B output ports. Identical data appear at the two output ports when the same address is applied to both address ports. The latches at the RAM output ports are transparent when the clock input, CP, is HIGH and they hold the RAM output data when CP is LOW. Under control of the  $\overline{OE}_B$  three-state output enable, RAM data can be read directly at the Am2903 DB I/O port. On the Am29203,  $E_A$  provides the same feature at the DA port.

External data at the Am2903/29203 Y I/O port can be written directly into the RAM, or ALU shifter output data can be enabled onto the Y I/O port and entered into the RAM. Data is written into the RAM at the B address when the write enable input,  $\overline{WE}$ , is LOW and the clock input, CP, is LOW.

### Arithmetic Logic Unit

The Am2903 high-performance ALU can perform seven arithmetic and nine logic operations on two 4-bit operands. Multiplexers at the ALU inputs provide the capability to select various pairs of ALU source operands. The  $\overline{E}_A$  input selects either the DA external data input or RAM output port A for use as one ALU operand and the  $\overline{OE}_B$  and  $I_0$  inputs select RAM output port B, DB external data input, or the Q Register content for use as the second ALU operand. Also, during some ALU operations, zeroes are forced at the ALU operand inputs. Thus, the Am2903 ALU can operate on data from two external sources, from an internal and external source, or from two internal sources. Table 1 shows all possible pairs of ALU source operands as a function of the  $\overline{E}_A$ ,  $\overline{OE}_B$ , and  $I_0$  inputs.

When instruction bits  $I_4$ ,  $I_3$ ,  $I_2$ ,  $I_1$ , and  $I_0$  are LOW, the Am2903 executes special functions. Table 4 defines these special functions and the operation which the ALU performs for each. When the Am2903 executes instructions other than the nine special functions, the ALU operation is determined by instruction bits  $I_4$ ,  $I_3$ ,  $I_2$ , and  $I_1$ . Table 2 defines the ALU operation as a function of these four instruction bits. The Am29203 ALU is identical, but executes 16 special instructions.

Am2903/29203s may be cascaded in either a ripple carry or lookahead carry fashion. When a number of Am2903/29203s are cascaded, each slice must be programmed to be a most significant slice (MSS), intermediate slice (IS), or least significant slice (LSS) of the array. The carry generate,  $\overline{G}$ , and carry propagate,  $\overline{P}$ , signals required for a lookahead carry scheme are generated by the Am2903/29203 and are available as outputs of the least significant and intermediate slices.

|   |   |   |                   |                   |
|---|---|---|-------------------|-------------------|
| L | L | L | RAM Output A      | RAM Output B      |
| L | L | H | RAM Output A      | DB <sub>0-3</sub> |
| L | H | X | RAM Output A      | Q Register        |
| H | L | L | DA <sub>0-3</sub> | RAM Output B      |
| H | L | H | DA <sub>0-3</sub> | DB <sub>0-3</sub> |
| H | H | X | DA <sub>0-3</sub> | Q Register        |

L = LOW

H = HIGH

X = Don't Care

TABLE 2. ALU FUNCTIONS

| $I_4$ | $I_3$ | $I_2$ | $I_1$ | $I_0$ | ALU Functions   |
|-------|-------|-------|-------|-------|---|
| L     | L     | L     | L     | L     | Special Functions   |
| L     | L     | L     | L     | H     | $F_i = \text{HIGH}$   |
| L     | L     | L     | H     | X     | $F = S \text{ Minus } R \text{ Minus } 1 \text{ Plus } C_n$ |
| L     | L     | H     | L     | X     | $F = R \text{ Minus } S \text{ Minus } 1 \text{ Plus } C_n$ |
| L     | L     | H     | H     | X     | $F = R \text{ Plus } S \text{ Plus } C_n$                   |
| L     | H     | L     | L     | X     | $F = S \text{ Plus } C_n$                                   |
| L     | H     | L     | H     | X     | $F = S \text{ Plus } C_n$                                   |
| L     | H     | H     | L     | L     | Reserved Special Functions                                  |
| L     | H     | H     | L     | H     | $F = R \text{ Plus } C_n$                                   |
| L     | H     | H     | H     | L     | Reserved Special Functions                                  |
| L     | H     | H     | H     | H     | $F = R \text{ Plus } C_n$                                   |
| H     | L     | L     | L     | L     | Reserved Special Functions                                  |
| H     | L     | L     | L     | H     | $F_i = \text{LOW}$  |
| H     | L     | L     | H     | X     | $F_i = R_i \text{ AND } S_i$                                |
| H     | L     | H     | L     | X     | $F_i = R_i \text{ EXCLUSIVE NOR } S_i$                      |
| H     | L     | H     | H     | X     | $F_i = R_i \text{ EXCLUSIVE OR } S_i$                       |
| H     | H     | L     | L     | X     | $F_i = R_i \text{ AND } S_i$                                |
| H     | H     | L     | H     | X     | $F_i = R_i \text{ NOR } S_i$                                |
| H     | H     | H     | L     | X     | $F_i = R_i \text{ NAND } S_i$                               |
| H     | H     | H     | H     | X     | $F_i = R_i \text{ OR } S_i$                                 |

L = LOW

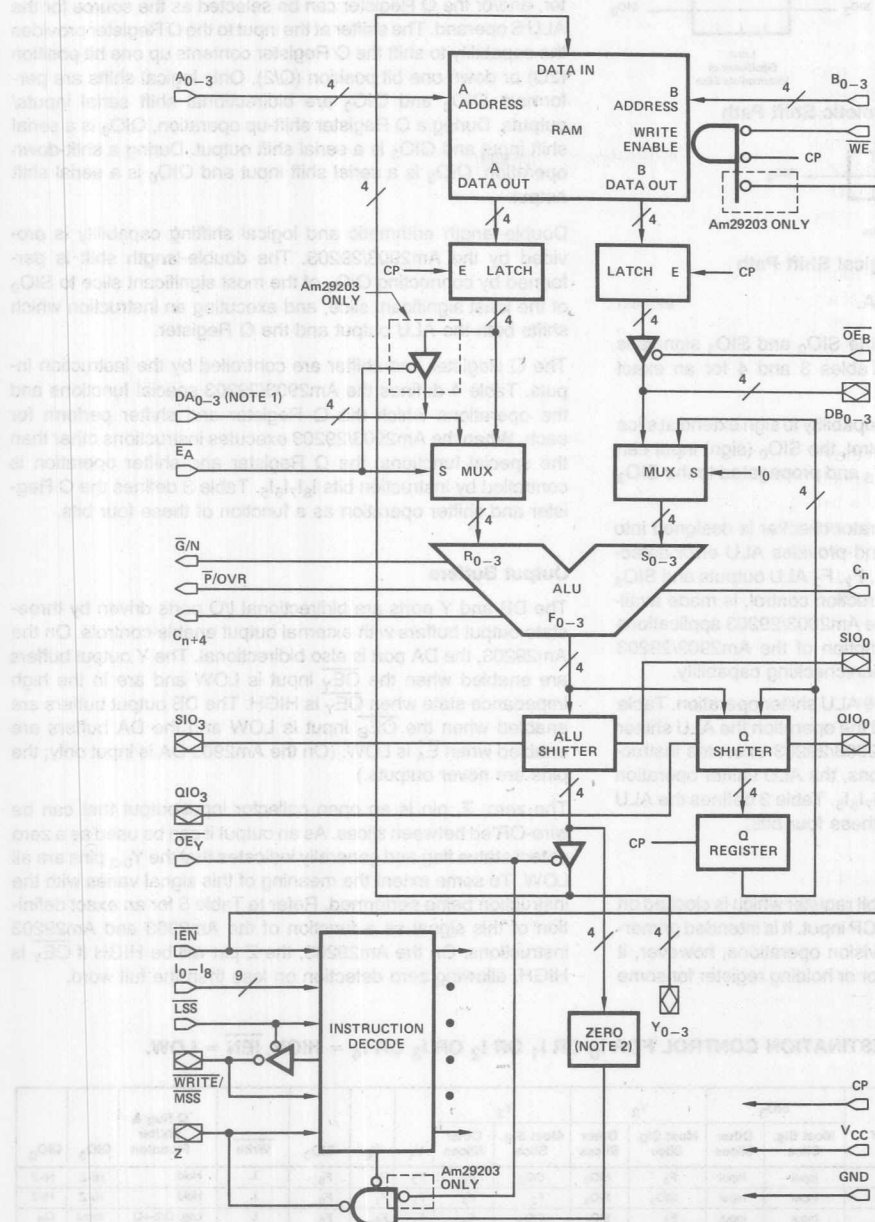
H = HIGH

i = 0 to 3

X = LOW or HIGH

The Am2903/29203 also generates a carry-out signal,  $C_{n+4}$ , which is generally available as an output of each slice. Both the carry-in,  $C_n$ , and carry-out,  $C_{n+4}$ , signals are active HIGH. The ALU generates two other status outputs. These are negative, N, and overflow, OVR. The N output is generally the most significant (sign) bit of the ALU output and can be used to determine positive or negative results. The OVR output indicates that the arithmetic operation being performed exceeds the available two's complement number range. The N and OVR signals are available as outputs of the most significant slice. Thus, the multipurpose  $\overline{G}/N$  and  $\overline{P}/OVR$  outputs indicate  $\overline{G}$  and  $\overline{P}$  at the least significant and intermediate slices, and sign and overflow at the most significant slice. To some extent, the meaning of the  $C_{n+4}$ ,  $\overline{P}/OVR$ , and  $\overline{G}/N$  signals vary with the ALU function being performed. Refer to Table 5 for an exact definition of these four signals as a function of the Am2903/29203 instruction.

## BLOCK DIAGRAM



Notes: 1. DA0-3 is input only on Am2903, but is I/O port on Am29203.

2. On Am2903, zero logic is connected to Y, after the OEY buffer.

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**ALU Shifter**

Under instruction control, the ALU shifter passes the ALU output (F) non-shifted, shifts it up one bit position (2F), or shifts it down one bit position (F/2). Both arithmetic and logical shift operations are possible. An arithmetic shift operation shifts data around the most significant (sign) bit position of the most significant slice,

and a logical shift operation shifts data through this bit position (see Figure A). SIO0 and SIO3 are bidirectional serial shift inputs/outputs. During a shift-up operation, SIO0 is generally a serial shift input and SIO3 a serial shift output. During a shift-down operation, SIO3 is generally a serial shift input and SIO0 a serial shift output.

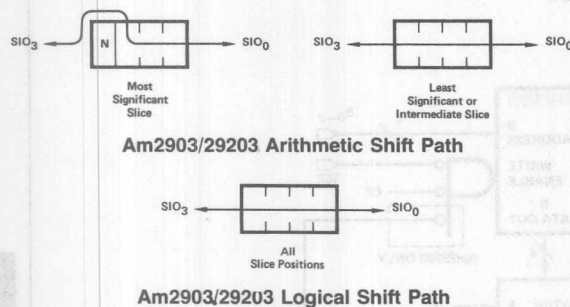


Figure A.

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To some extent, the meaning of the  $SIO_0$  and  $SIO_3$  signals is instruction dependent. Refer to Tables 3 and 4 for an exact definition of these pins.

The ALU shifter also provides the capability to sign extend at slice boundaries. Under instruction control, the  $SIO_0$  (sign) input can be extended through  $Y_0$ ,  $Y_1$ ,  $Y_2$ ,  $Y_3$  and propagated to the  $SIO_3$  output.

A cascable, five-bit parity generator/checker is designed into the Am2903/29203 ALU shifter and provides ALU error detection capability. Parity for the  $F_0$ ,  $F_1$ ,  $F_2$ ,  $F_3$  ALU outputs and  $SIO_3$  input is generated and, under instruction control, is made available at the  $SIO_0$  output. Refer to the Am2903/29203 applications section for a more detailed description of the Am2903/29203 sign extension and parity generation/checking capability.

The instruction inputs determine the ALU shifter operation. Table 4 defines the special functions and the operation the ALU shifter performs for each. When the Am2903/29203 executes instructions other than the special functions, the ALU shifter operation is determined by instruction bits  $I_8 I_7 I_6 I_5$ . Table 3 defines the ALU shifter operation as a function of these four bits.

### Q Register

The Q Register is an auxiliary four-bit register which is clocked on the LOW-to-HIGH transition of the CP input. It is intended primarily for use in multiplication and division operations; however, it can also be used as an accumulator or holding register for some

applications. The ALU output,  $F$ , can be loaded into the Q Register, and/or the Q Register can be selected as the source for the ALU S operand. The shifter at the input to the Q Register provides the capability to shift the Q Register contents up one bit position ( $2Q$ ) or down one bit position ( $Q/2$ ). Only logical shifts are performed.  $QIO_0$  and  $QIO_3$  are bidirectional shift serial inputs/outputs. During a Q Register shift-up operation,  $QIO_0$  is a serial shift input and  $QIO_3$  is a serial shift output. During a shift-down operation,  $QIO_3$  is a serial shift input and  $QIO_0$  is a serial shift output.

Double-length arithmetic and logical shifting capability is provided by the Am2903/29203. The double-length shift is performed by connecting  $QIO_3$  of the most significant slice to  $SIO_0$  of the least significant slice, and executing an instruction which shifts both the ALU output and the Q Register.

The Q Register and shifter are controlled by the instruction inputs. Table 4 defines the Am2903/29203 special functions and the operations which the Q Register and shifter perform for each. When the Am2903/29203 executes instructions other than the special functions, the Q Register and shifter operation is controlled by instruction bits  $I_8 I_7 I_6 I_5$ . Table 3 defines the Q Register and shifter operation as a function of these four bits.

### Output Buffers

The DB and Y ports are bidirectional I/O ports driven by three-state output buffers with external output enable controls. On the Am29203, the DA port is also bidirectional. The Y output buffers are enabled when the  $\overline{OE}_Y$  input is LOW and are in the high impedance state when  $\overline{OE}_Y$  is HIGH. The DB output buffers are enabled when the  $\overline{OE}_B$  input is LOW and the DA buffers are enabled when  $\overline{E}_A$  is LOW. (On the Am2903 DA is input only; the pins are never outputs.)

The zero, Z, pin is an open collector input/output that can be wire-OR'ed between slices. As an output it can be used as a zero detect status flag and generally indicates that the  $Y_{0-3}$  pins are all LOW. To some extent the meaning of this signal varies with the instruction being performed. Refer to Table 5 for an exact definition of this signal as a function of the Am2903 and Am29203 instructions. On the Am29203, the Z pin will be HIGH if  $\overline{OE}_Y$  is HIGH, allowing zero detection on less than the full word.

TABLE 3. ALU DESTINATION CONTROL FOR  $I_0$  OR  $I_1$  OR  $I_2$  OR  $I_3$  OR  $I_4$  = HIGH,  $\overline{IEN}$  = LOW.

| $I_8$ | $I_7$ | $I_6$ | $I_5$ | Hex Code | ALU Shifter Function                   | $SIO_3$         |              | $Y_3$           |              | $Y_2$           |              | $Y_1$   | $Y_0$   | $SIO_0$ | Write | Q Reg & Shifter Function | $QIO_3$ | $QIO_0$ |
|-------|-------|-------|-------|----------|--|-----------------|--------------|-----------------|--------------|-----------------|--------------|---------|---------|---------|-------|--------------------------|---------|---------|
|       |       |       |       |          |  | Most Sig. Slice | Other Slices | Most Sig. Slice | Other Slices | Most Sig. Slice | Other Slices |         |         |         |       |                          |         |         |
| L     | L     | L     | L     | 0        | Arith. $F/2 \rightarrow Y$             | Input           | Input        | $F_3$           | $SIO_3$      | $SIO_3$         | $F_3$        | $F_2$   | $F_1$   | $F_0$   | L     | Hold                     | Hi-Z    | Hi-Z    |
| L     | L     | L     | H     | 1        | Log. $F/2 \rightarrow Y$               | Input           | Input        | $SIO_3$         | $SIO_3$      | $F_3$           | $F_3$        | $F_2$   | $F_1$   | $F_0$   | L     | Hold                     | Hi-Z    | Hi-Z    |
| L     | L     | H     | L     | 2        | Arith. $F/2 \rightarrow Y$             | Input           | Input        | $F_3$           | $SIO_3$      | $SIO_3$         | $F_3$        | $F_2$   | $F_1$   | $F_0$   | L     | Log. $Q/2 \rightarrow Q$ | Input   | $Q_0$   |
| L     | L     | H     | H     | 3        | Log. $F/2 \rightarrow Y$               | Input           | Input        | $SIO_3$         | $SIO_3$      | $F_3$           | $F_3$        | $F_2$   | $F_1$   | $F_0$   | L     | Log. $Q/2 \rightarrow Q$ | Input   | $Q_0$   |
| L     | H     | L     | L     | 4        | $F \rightarrow Y$                      | Input           | Input        | $F_3$           | $F_3$        | $F_2$           | $F_2$        | $F_1$   | $F_0$   | Parity  | L     | Hold                     | Hi-Z    | Hi-Z    |
| L     | H     | L     | H     | 5        | $F \rightarrow Y$                      | Input           | Input        | $F_3$           | $F_3$        | $F_2$           | $F_2$        | $F_1$   | $F_0$   | Parity  | H     | Log. $Q/2 \rightarrow Q$ | Input   | $Q_0$   |
| L     | H     | H     | L     | 6        | $F \rightarrow Y$                      | Input           | Input        | $F_3$           | $F_3$        | $F_2$           | $F_2$        | $F_1$   | $F_0$   | Parity  | H     | $F \rightarrow Q$        | Hi-Z    | Hi-Z    |
| L     | H     | H     | H     | 7        | $F \rightarrow Y$                      | Input           | Input        | $F_3$           | $F_3$        | $F_2$           | $F_2$        | $F_1$   | $F_0$   | Parity  | L     | $F \rightarrow Q$        | Hi-Z    | Hi-Z    |
| H     | L     | L     | L     | 8        | Arith. $2F \rightarrow Y$              | $F_2$           | $F_3$        | $F_3$           | $F_2$        | $F_1$           | $F_1$        | $F_0$   | $SIO_0$ | Input   | L     | Hold                     | Hi-Z    | Hi-Z    |
| H     | L     | L     | H     | 9        | Log. $2F \rightarrow Y$                | $F_2$           | $F_3$        | $F_2$           | $F_2$        | $F_1$           | $F_1$        | $F_0$   | $SIO_0$ | Input   | L     | Hold                     | Hi-Z    | Hi-Z    |
| H     | L     | H     | L     | A        | Arith. $2F \rightarrow Y$              | $F_2$           | $F_3$        | $F_3$           | $F_2$        | $F_1$           | $F_1$        | $F_0$   | $SIO_0$ | Input   | L     | Log. $2Q \rightarrow Q$  | $Q_3$   | Input   |
| H     | L     | H     | H     | B        | Log. $2F \rightarrow Y$                | $F_2$           | $F_3$        | $F_2$           | $F_2$        | $F_1$           | $F_1$        | $F_0$   | $SIO_0$ | Input   | L     | Log. $2Q \rightarrow Q$  | $Q_3$   | Input   |
| H     | H     | L     | L     | C        | $F \rightarrow Y$                      | $F_3$           | $F_3$        | $F_3$           | $F_3$        | $F_2$           | $F_2$        | $F_1$   | $F_0$   | Hi-Z    | H     | Hold                     | Hi-Z    | Hi-Z    |
| H     | H     | L     | H     | D        | $F \rightarrow Y$                      | $F_3$           | $F_3$        | $F_3$           | $F_3$        | $F_2$           | $F_2$        | $F_1$   | $F_0$   | Hi-Z    | H     | Log. $2Q \rightarrow Q$  | $Q_3$   | Input   |
| H     | H     | H     | L     | E        | $SIO_0 \rightarrow Y_0, Y_1, Y_2, Y_3$ | $SIO_0$         | $SIO_0$      | $SIO_0$         | $SIO_0$      | $SIO_0$         | $SIO_0$      | $SIO_0$ | $SIO_0$ | Input   | L     | Hold                     | Hi-Z    | Hi-Z    |
| H     | H     | H     | H     | F        | $F \rightarrow Y$                      | $F_3$           | $F_3$        | $F_3$           | $F_3$        | $F_2$           | $F_2$        | $F_1$   | $F_0$   | Hi-Z    | L     | Hold                     | Hi-Z    | Hi-Z    |

Parity =  $F_3 \oplus F_2 \oplus F_1 \oplus F_0 \oplus SIO_3$   
 $\oplus$  = Exclusive OR

L = LOW  
H = HIGH

Hi-Z = High Impedance



TABLE 4. SPECIAL FUNCTIONS:  $I_0 = I_1 = I_2 = I_3 = I_4 = \text{LOW}$ ,  $\overline{\text{IEN}} = \text{LOW}$ 

| $I_8$ | $I_7$ | $I_6$ | $I_5$ | Hex Code | Available On      | Special Function                                  | ALU Function   | ALU Shifter Function   | SIO <sub>3</sub> |                | SIO <sub>0</sub> | Q Reg & Shifter Function | QIO <sub>3</sub> | QIO <sub>0</sub> | WRITE |
|-------|-------|-------|-------|----------|-------------------|---|--|------------------------|------------------|----------------|------------------|--------------------------|------------------|------------------|-------|
|       |       |       |       |          |                   |   |  |                        | Most Sig. Slice  | Other Slices   |                  |                          |                  |                  |       |
| L     | L     | L     | L     | 0        | Am2903<br>Am29203 | Unsigned Multiply                                 | $F = S + C_n$ if $Z = L$<br>$F = R + S + C_n$ if $Z = H$         | Log. F/2→Y<br>(Note 1) | Hi-Z             | Input          | F <sub>0</sub>   | Log. Q/2→Q               | Input            | Q <sub>0</sub>   | L     |
| L     | L     | L     | H     | 1        | Am29203           |   |  |                        |                  |                |                  |                          |                  |                  |       |
| L     | L     | H     | L     | 2        | Am2903<br>Am29203 | Two's Complement Multiply                         | $F = S + C_n$ if $Z = L$<br>$F = R + S + C_n$ if $Z = H$         | Log. F/2→Y<br>(Note 2) | Hi-Z             | Input          | F <sub>0</sub>   | Log. Q/2→Q               | Input            | Q <sub>0</sub>   | L     |
| L     | L     | H     | H     | 3        | Am29203           |   |  |                        |                  |                |                  |                          |                  |                  |       |
| L     | H     | L     | L     | 4        | Am2903<br>Am29203 | Increment by One or Two                           | $F = S + 1 + C_n$  | F→Y                    | Input            | Input          | Parity           | Hold                     | Hi-Z             | Hi-Z             | L     |
| L     | H     | L     | H     | 5        | Am2903<br>Am29203 | Sign/Magnitude-<br>Two's Complement               | $F = S + C_n$ if $Z = L$<br>$F = S + C_n$ if $Z = H$             | F→Y<br>(Note 3)        | Input            | Input          | Parity           | Hold                     | Hi-Z             | Hi-Z             | L     |
| L     | H     | H     | L     | 6        | Am2903<br>Am29203 | Two's Complement Multiply, Last Cycle             | $F = S + C_n$ if $Z = L$<br>$F = S - R - 1 + C_n$ if $Z = H$     | Log. F/2→Y<br>(Note 2) | Hi-Z             | Input          | F <sub>0</sub>   | Log. Q/2→Q               | Input            | Q <sub>0</sub>   | L     |
| L     | H     | H     | H     | 7        | Am29203           |   |  |                        |                  |                |                  |                          |                  |                  |       |
| H     | L     | L     | L     | 8        | Am2903<br>Am29203 | Single Length Normalize                           | $F = S + C_n$  | F→Y                    | F <sub>3</sub>   | F <sub>3</sub> | Hi-Z             | Log. 2Q→Q                | Q <sub>3</sub>   | Input            | L     |
| H     | L     | L     | H     | 9        | Am29203           |   |  |                        |                  |                |                  |                          |                  |                  |       |
| H     | L     | H     | L     | A        | Am2903<br>Am29203 | Double Length Normalize and First Divide Op.      | $F = S + C_n$  | Log. 2F→Y              | $R_3 \nabla F_3$ | F <sub>3</sub> | Input            | Log. 2Q→Q                | Q <sub>3</sub>   | Input            | L     |
| H     | L     | H     | H     | B        | Am29203           |   |  |                        |                  |                |                  |                          |                  |                  |       |
| H     | H     | L     | L     | C        | Am2903<br>Am29203 | Two's Complement Divide                           | $F = S + R + C_n$ if $Z = L$<br>$F = S - R - 1 + C_n$ if $Z = H$ | Log. 2F→Y              | $R_3 \nabla F_3$ | F <sub>3</sub> | Input            | Log. 2Q→Q                | Q <sub>3</sub>   | Input            | L     |
| H     | H     | L     | H     | D        | Am29203           |   |  |                        |                  |                |                  |                          |                  |                  |       |
| H     | H     | H     | L     | E        | Am2903<br>Am29203 | Two's Complement Divide, Correction and Remainder | $F = S + R + C_n$ if $Z = L$<br>$F = S - R - 1 + C_n$ if $Z = H$ | F→Y                    | F <sub>3</sub>   | F <sub>3</sub> | Hi-Z             | Log. 2Q→Q                | Q <sub>3</sub>   | Input            |       |
| H     | H     | H     | H     | F        | Am29203           |   |  |                        |                  |                |                  |                          |                  |                  |       |

NOTES: 1. At the most significant slice only, the  $C_{n+4}$  signal is internally gated to the Y<sub>3</sub> output.  
 2. At the most significant slice only,  $F_3 \nabla \text{OVR}$  is internally gated to the Y<sub>3</sub> output.  
 3. At the most significant slice only,  $S_3 \nabla F_3$  is generated at the Y<sub>3</sub> output.

L = LOW  
 H = HIGH  
 X = Don't Care

Hi-Z = High Impedance  
 $\nabla$  = Exclusive OR  
 Parity =  $\text{SIO}_3 \nabla F_3 \nabla F_2 \nabla F_1 \nabla F_0$

### Instruction Decoder

The Instruction Decoder generates required internal control signals as a function of the nine Instruction inputs,  $I_0$ – $I_8$ ; the Instruction Enable input,  $\overline{\text{IEN}}$ ; the  $\overline{\text{LSS}}$  input; and the  $\overline{\text{WRITE/MSS}}$  input/output.

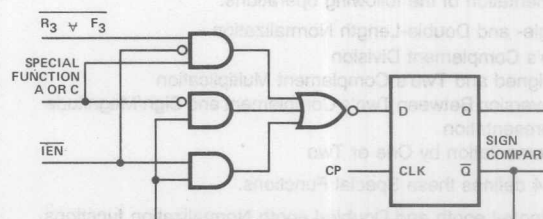
The  $\overline{\text{WRITE}}$  output is LOW when an instruction which writes data into the RAM is being executed. Refer to Tables 3 and 4 for a definition of the  $\overline{\text{WRITE}}$  output as a function of the Am2903 instruction inputs.

On the Am2903, when  $\overline{\text{IEN}}$  is HIGH, the  $\overline{\text{WRITE}}$  output is forced HIGH and the Q Register and Sign Compare Flip-Flop contents are preserved. When  $\overline{\text{IEN}}$  is LOW, the  $\overline{\text{WRITE}}$  output is enabled and the Q Register and Sign Compare Flip-Flop can be written according to the Am2903 instruction. The Sign Compare Flip-Flop is an on-chip flip-flop which is used during an Am2903 divide operation (see Figure B). On the Am29203,  $\overline{\text{IEN}}$  controls internal writing, but does not affect  $\overline{\text{WRITE}}$ . The  $\overline{\text{IEN}}$  signal can then be controlled separately at each chip to facilitate byte operations.

### Programming the Am2903/29203 Slice Position

Tying the  $\overline{\text{LSS}}$  input LOW programs the slice to operate as a least significant slice (LSS) and enables the  $\overline{\text{WRITE}}$  output signal onto the  $\overline{\text{WRITE/MSS}}$  bidirectional I/O pin. When  $\overline{\text{LSS}}$  is tied HIGH, the  $\overline{\text{WRITE/MSS}}$  pin becomes an input pin; tying the  $\overline{\text{WRITE/MSS}}$  pin

HIGH programs the slice to operate as an intermediate slice (IS) and tying it LOW programs the slice to operate as a most significant slice (MSS). The  $\overline{\text{W/MSS}}$  pin must be tied HIGH through a resistor.  $\overline{\text{W/MSS}}$  and  $\overline{\text{LSS}}$  should not be connected together. See Figure 2 of applications.



The sign compare signal appears at the Z output of the most significant slice during special functions C, D and E, F. Refer to Table 5.

Figure B. Sign Compare Flip-Flop.

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TABLE 5. Am2903/29203 STATUS OUTPUTS

| (Hex)<br>I <sub>8</sub> I <sub>7</sub> I <sub>6</sub> I <sub>5</sub> | (Hex)<br>I <sub>4</sub> I <sub>3</sub> I <sub>2</sub> I <sub>1</sub> | I <sub>0</sub> | GI<br>(I=0 to 3)   | PI<br>(I=0 to 3)   | C <sub>n+4</sub>    | P/OVR                               |                 | G/N   |                 | Z (OE <sub>V</sub> = LOW)                                   |   |   |
|--|--|----------------|--|--|---------------------|-------------------------------------|-----------------|---|-----------------|---|---|---|
|  |  |                |  |  |                     | Most Sig.<br>Slice                  | Other<br>Slices | Most Sig.<br>Slice  | Other<br>Slices | Most Sig.<br>Slice  | Intermediate<br>Slices                                      | Least Sig<br>Slice  |
| X  | 0  | H              | 0  | 1  | 0                   | 0                                   | 0               | F <sub>3</sub>  | G               | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> |
| X  | 1  | X              | R <sub>i</sub> ∧ S <sub>i</sub>  | R <sub>i</sub> ∨ S <sub>i</sub>  | G ∨ PC <sub>n</sub> | C <sub>n+3</sub> ∨ C <sub>n+4</sub> | P               | F <sub>3</sub>  | G               | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> |
| X  | 2  | X              | R <sub>i</sub> ∧ S <sub>i</sub>  | R <sub>i</sub> ∨ S <sub>i</sub>  | G ∨ PC <sub>n</sub> | C <sub>n+3</sub> ∨ C <sub>n+4</sub> | P               | F <sub>3</sub>  | G               | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> |
| X  | 3  | X              | R <sub>i</sub> ∧ S <sub>i</sub>  | R <sub>i</sub> ∨ S <sub>i</sub>  | G ∨ PC <sub>n</sub> | C <sub>n+3</sub> ∨ C <sub>n+4</sub> | P               | F <sub>3</sub>  | G               | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> |
| X  | 4  | X              | 0  | S <sub>i</sub>   | G ∨ PC <sub>n</sub> | C <sub>n+3</sub> ∨ C <sub>n+4</sub> | P               | F <sub>3</sub>  | G               | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> |
| X  | 5  | X              | 0  | S <sub>i</sub>   | G ∨ PC <sub>n</sub> | C <sub>n+3</sub> ∨ C <sub>n+4</sub> | P               | F <sub>3</sub>  | G               | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> |
| X  | 6  | X              | 0  | R <sub>i</sub>   | G ∨ PC <sub>n</sub> | C <sub>n+3</sub> ∨ C <sub>n+4</sub> | P               | F <sub>3</sub>  | G               | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> |
| X  | 7  | X              | 0  | R <sub>i</sub>   | G ∨ PC <sub>n</sub> | C <sub>n+3</sub> ∨ C <sub>n+4</sub> | P               | F <sub>3</sub>  | G               | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> |
| X  | 8  | X              | 0  | 1  | 0                   | 0                                   | 0               | F <sub>3</sub>  | G               | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> |
| X  | 9  | X              | R <sub>i</sub> ∧ S <sub>i</sub>  | 1  | 0                   | 0                                   | 0               | F <sub>3</sub>  | G               | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> |
| X  | A  | X              | R <sub>i</sub> ∧ S <sub>i</sub>  | R <sub>i</sub> ∨ S <sub>i</sub>  | 0                   | 0                                   | 0               | F <sub>3</sub>  | G               | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> |
| X  | B  | X              | R <sub>i</sub> ∧ S <sub>i</sub>  | R <sub>i</sub> ∨ S <sub>i</sub>  | 0                   | 0                                   | 0               | F <sub>3</sub>  | G               | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> |
| X  | C  | X              | R <sub>i</sub> ∧ S <sub>i</sub>  | 1  | 0                   | 0                                   | 0               | F <sub>3</sub>  | G               | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> |
| X  | D  | X              | R <sub>i</sub> ∧ S <sub>i</sub>  | 1  | 0                   | 0                                   | 0               | F <sub>3</sub>  | G               | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> |
| X  | E  | X              | R <sub>i</sub> ∧ S <sub>i</sub>  | 1  | 0                   | 0                                   | 0               | F <sub>3</sub>  | G               | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> |
| X  | F  | X              | R <sub>i</sub> ∧ S <sub>i</sub>  | 1  | 0                   | 0                                   | 0               | F <sub>3</sub>  | G               | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> |
| 0  | 0  | L              | 0 if Z=L<br>R <sub>i</sub> ∧ S <sub>i</sub> if Z=H                               | S <sub>i</sub> if Z=L<br>R <sub>i</sub> ∨ S <sub>i</sub> if Z=H                  | G ∨ PC <sub>n</sub> | C <sub>n+3</sub> ∨ C <sub>n+4</sub> | P               | F <sub>3</sub>  | G               | Input   | Input   | Q <sub>0</sub>  |
| 2  | 0  | L              | 0 if Z=L<br>R <sub>i</sub> ∧ S <sub>i</sub> if Z=H                               | S <sub>i</sub> if Z=L<br>R <sub>i</sub> ∨ S <sub>i</sub> if Z=H                  | G ∨ PC <sub>n</sub> | C <sub>n+3</sub> ∨ C <sub>n+4</sub> | P               | F <sub>3</sub>  | G               | Input   | Input   | Q <sub>0</sub>  |
| 4  | 0  | L              | See Note 1   | See Note 2   | G ∨ PC <sub>n</sub> | C <sub>n+3</sub> ∨ C <sub>n+4</sub> | P               | F <sub>3</sub>  | G               | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> | Y <sub>0</sub> Y <sub>1</sub> Y <sub>2</sub> Y <sub>3</sub> |
| 5  | 0  | L              | 0  | S <sub>i</sub> if Z=L<br>S <sub>i</sub> if Z=H                                   | G ∨ PC <sub>n</sub> | C <sub>n+3</sub> ∨ C <sub>n+4</sub> | P               | F <sub>3</sub> if Z=L<br>F <sub>3</sub> ∨ S <sub>3</sub> if Z=H | G               | S <sub>3</sub>  | Input   | Input   |
| 6  | 0  | L              | 0 if Z=L<br>R <sub>i</sub> ∧ S <sub>i</sub> if Z=H                               | S <sub>i</sub> if Z=L<br>R <sub>i</sub> ∨ S <sub>i</sub> if Z=H                  | G ∨ PC <sub>n</sub> | C <sub>n+3</sub> ∨ C <sub>n+4</sub> | P               | F <sub>3</sub>  | G               | Input   | Input   | Q <sub>0</sub>  |
| 8  | 0  | L              | 0  | S <sub>i</sub>   | See Note 3          | Q <sub>2</sub> ∨ Q <sub>1</sub>     | P               | Q <sub>3</sub>  | G               | Q <sub>0</sub> Q <sub>1</sub> Q <sub>2</sub> Q <sub>3</sub> | Q <sub>0</sub> Q <sub>1</sub> Q <sub>2</sub> Q <sub>3</sub> | Q <sub>0</sub> Q <sub>1</sub> Q <sub>2</sub> Q <sub>3</sub> |
| A  | 0  | L              | 0  | S <sub>i</sub>   | See Note 4          | F <sub>2</sub> ∨ F <sub>1</sub>     | P               | F <sub>3</sub>  | G               | See Note 5  | See Note 5  | See Note 5  |
| C  | 0  | L              | R <sub>i</sub> ∧ S <sub>i</sub> if Z=L<br>R <sub>i</sub> ∧ S <sub>i</sub> if Z=H | R <sub>i</sub> ∨ S <sub>i</sub> if Z=L<br>R <sub>i</sub> ∨ S <sub>i</sub> if Z=H | G ∨ PC <sub>n</sub> | C <sub>n+3</sub> ∨ C <sub>n+4</sub> | P               | F <sub>3</sub>  | G               | Sign Compare<br>FF Output                                   | Input   | Input   |
| E  | 0  | L              | R <sub>i</sub> ∧ S <sub>i</sub> if Z=L<br>R <sub>i</sub> ∧ S <sub>i</sub> if Z=H | R <sub>i</sub> ∨ S <sub>i</sub> if Z=L<br>R <sub>i</sub> ∨ S <sub>i</sub> if Z=H | G ∨ PC <sub>n</sub> | C <sub>n+3</sub> ∨ C <sub>n+4</sub> | P               | F <sub>3</sub>  | G               | Sign Compare<br>FF Output                                   | Input   | Input   |

L = LOW = 0

H = HIGH = 1

V = OR

Λ = AND

∨ = EXCLUSIVE OR

P = P<sub>3</sub>P<sub>2</sub>P<sub>1</sub>P<sub>0</sub>G = G<sub>3</sub>G<sub>2</sub>G<sub>1</sub>G<sub>0</sub>P<sub>3</sub>P<sub>2</sub>P<sub>1</sub>P<sub>0</sub>C<sub>n+3</sub> = G<sub>2</sub>∨G<sub>1</sub>P<sub>2</sub>∨G<sub>0</sub>P<sub>1</sub>P<sub>2</sub>∨C<sub>n</sub>P<sub>3</sub>P<sub>1</sub>P<sub>2</sub>NOTES: 1. If LSS is LOW, G<sub>0</sub> = S<sub>0</sub> and G<sub>1,2,3</sub> = 0If LSS is HIGH, G<sub>0,1,2,3</sub> = 02. If LSS is LOW, P<sub>0</sub> = 1 and P<sub>1,2,3</sub> = S<sub>1,2,3</sub>If LSS is HIGH, P<sub>1</sub> = S<sub>1</sub>3. At the most significant slice, C<sub>n+4</sub> = Q<sub>3</sub>∨Q<sub>2</sub>At other slices, C<sub>n+4</sub> = G ∨ PC<sub>n</sub>4. At the most significant slice, C<sub>n+4</sub> = F<sub>3</sub>∨F<sub>2</sub>At other slices, C<sub>n+4</sub> = G ∨ PC<sub>n</sub>5. Z = Q<sub>0</sub>Q<sub>1</sub>Q<sub>2</sub>Q<sub>3</sub>F<sub>0</sub>F<sub>1</sub>F<sub>2</sub>F<sub>3</sub>**Am2903 SPECIAL FUNCTIONS**

The Am2903 provides nine Special Functions which facilitate the implementation of the following operations:

- Single- and Double-Length Normalization
- Two's Complement Division
- Unsigned and Two's Complement Multiplication
- Conversion Between Two's Complement and Sign/Magnitude Representation
- Incrementation by One or Two

Table 4 defines these Special Functions.

The Single-Length and Double-Length Normalization functions can be used to adjust a single-precision or double-precision floating point number in order to bring its mantissa within a specified range.

Three Special Functions which can be used to perform a two's complement, non-restoring divide operation are provided by the Am2903. These functions provide both single- and double-precision divide operations and can be performed in "n" clock cycles, where "n" is the number of bits in the quotient.

The Unsigned Multiply Special Function and the two Two's Complement Multiply Special Functions can be used to multiply two n-bit, unsigned or two's complement numbers, respectively, in n clock cycles. These functions utilize the conditional add and shift algorithm. During the last cycle of the two's complement multiplication, a conditional subtraction, rather than addition, is performed because the sign bit of the multiplier carries negative weight.

The Sign/Magnitude-Two's Complement Special Function can be used to convert number representation systems. A number expressed in Sign/Magnitude representation can be converted to the Two's Complement representation, and vice-versa, in one clock cycle.

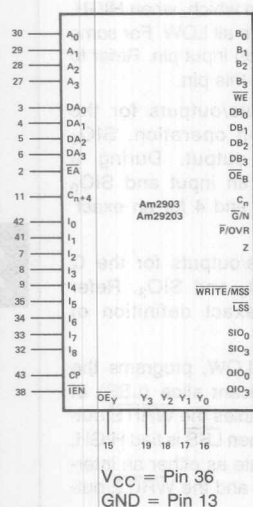
The Increment by One or Two Special Function can be used to increment an unsigned or two's complement number by one or two. This is useful in 16-bit word, byte-addressable machines, where the word addresses are multiples of two.

Refer to Am2903 applications section for a more detailed description of these Special Functions.

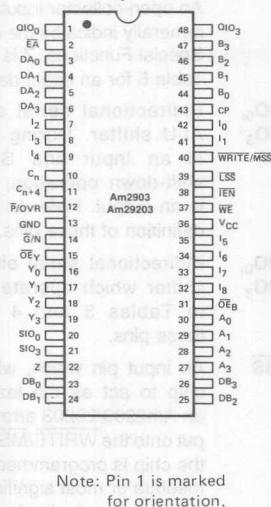
## PIN DEFINITIONS

|                                      |  |   |  |
|--------------------------------------|--|---|--|
| <b>A<sub>0-3</sub></b>               | Four RAM address inputs which contain the address of the RAM word appearing at the RAM A output port.  | <b>Z</b>  | An open-collector input/output pin which, when HIGH, generally indicates the outputs are all LOW. For some Special Functions, Z is used as an input pin. Refer to Table 5 for an exact definition of this pin.   |
| <b>B<sub>0-3</sub></b>               | Four RAM address inputs which contain the address of the RAM word appearing at the RAM B output port and into which new data is written when the $\overline{WE}$ input and the CP input are LOW.   | <b>SIO<sub>0</sub>, SIO<sub>3</sub></b>             | Bidirectional serial shift inputs/outputs for the ALU shifter. During a shift-up operation, SIO <sub>0</sub> is an input and SIO <sub>3</sub> an output. During a shift-down operation, SIO <sub>3</sub> is an input and SIO <sub>0</sub> is an output. Refer to Tables 3 and 4 for an exact definition of these pins.   |
| <b><math>\overline{WE}</math></b>    | The RAM write enable input. If $\overline{WE}$ is LOW, data at the Y I/O port is written into the RAM when the CP input is LOW. When $\overline{WE}$ is HIGH, writing data into the RAM is inhibited.  | <b>QIO<sub>0</sub>, QIO<sub>3</sub></b>             | Bidirectional serial shift inputs/outputs for the Q shifter which operate like SIO <sub>0</sub> and SIO <sub>3</sub> . Refer to Tables 3 and 4 for an exact definition of these pins.  |
| <b>DA<sub>0-3</sub></b>              | A four-bit external data input which can be selected as one of the Am2903 ALU operand sources; DA <sub>0</sub> is the least significant bit. On the Am29203, the DA path is bidirectional, operating as either an ALU source operand or as an external output for the RAM A-port.  | <b><math>\overline{LSS}</math></b>                  | An input pin which, when tied LOW, programs the chip to act as the least significant slice ( $\overline{LSS}$ ) of an Am2903/29203 array and enables the $\overline{WRITE}$ output onto the $\overline{WRITE}/\overline{MSS}$ pin. When $\overline{LSS}$ is tied HIGH, the chip is programmed to operate as either an intermediate or most significant slice and the $\overline{WRITE}$ output buffer is disabled.   |
| <b><math>\overline{EA}</math></b>    | A control input which, when HIGH selects DA <sub>0-3</sub> as the ALU R operand, and, when LOW, selects RAM output A as the ALU R operand and the DA <sub>0-3</sub> output data.   | <b><math>\overline{WRITE}/\overline{MSS}</math></b> | When $\overline{LSS}$ is tied LOW, the $\overline{WRITE}$ output signal appears at this pin; the $\overline{WRITE}$ signal is LOW when an instruction which writes data into the RAM is being executed. When $\overline{LSS}$ is tied HIGH, $\overline{WRITE}/\overline{MSS}$ is an input pin; tying it HIGH programs the chip to operate as an intermediate slice (IS) and tying it LOW programs the chip to operate as the most significant slice (MSS). |
| <b>DB<sub>0-3</sub></b>              | A four-bit external data input/output. Under control of the $\overline{OE}_B$ input, RAM output port B can be directly read on these lines, or input data on these lines can be selected as the ALU S operand.   | <b>Y<sub>0-3</sub></b>                              | Four data inputs/outputs of the Am2903/29203. Under control of the $\overline{OE}_Y$ input, the ALU shifter output data can be enabled onto these lines, or these lines can be used as data inputs when external data is written directly into the RAM.  |
| <b><math>\overline{OE}_B</math></b>  | A control input which, when LOW, enables RAM output B onto the DB <sub>0-3</sub> lines and, when HIGH, disables the RAM output B tri-state buffers.  | <b><math>\overline{OE}_Y</math></b>                 | A control input which, when LOW, enables the ALU shifter output data onto the Y <sub>0-3</sub> lines and, when HIGH, disables the Y <sub>0-3</sub> three-state output buffers.   |
| <b>C<sub>n</sub></b>                 | The carry-in input to the Am2903/29203 ALU.  | <b>CP</b>   | The clock input to the Am2903/29203. The Q Register and Sign Compare flip-flop are clocked on the LOW-to-HIGH transition of the CP signal. When enabled by $\overline{WE}$ , data is written in the RAM when CP is LOW.  |
| <b>I<sub>0-8</sub></b>               | The nine instruction inputs used to select the Am2903/29203 operation to be performed.   |   |  |
| <b><math>\overline{IEN}</math></b>   | The instruction enable input which, when LOW, allows the Q Register and the Sign Compare flip-flop to be written. When $\overline{IEN}$ is HIGH, the Q Register and Sign Compare flip-flop are in the hold mode. On the Am2903, $\overline{IEN}$ also controls $\overline{WRITE}$ . On the Am29203, $\overline{WRITE}$ is not affected by $\overline{IEN}$ , but internally disables the RAM write enable. |   |  |
| <b>C<sub>n+4</sub></b>               | This output generally indicates the carry-out of the Am2903/29203 ALU. Refer to Table 5 for an exact definition of this pin.   |   |  |
| <b><math>\overline{G}/N</math></b>   | A multi-purpose pin which indicates the carry generate, $\overline{G}$ , function at the least significant and intermediate slices, and generally indicates the sign, N, of the ALU result at the most significant slice. Refer to Table 5 for an exact definition of this pin.  |   |  |
| <b><math>\overline{P}/OVR</math></b> | A multi-purpose pin which indicates the carry propagate, $\overline{P}$ , function at the least significant and intermediate slices, and indicates the conventional two's complement overflow, OVR, signal at the most significant slice. Refer to Table 5 for an exact definition of this pin.  |   |  |

## LOGIC SYMBOL

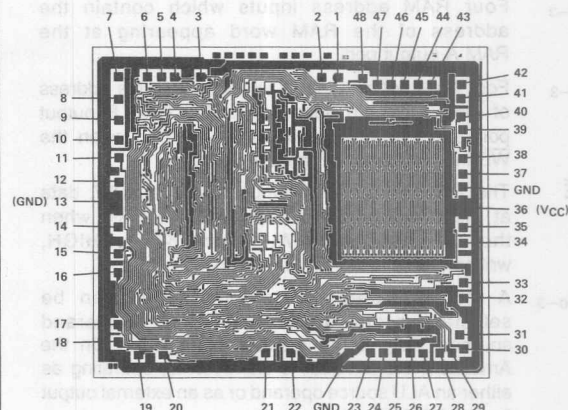


MPR-033

CONNECTION DIAGRAM  
Top View

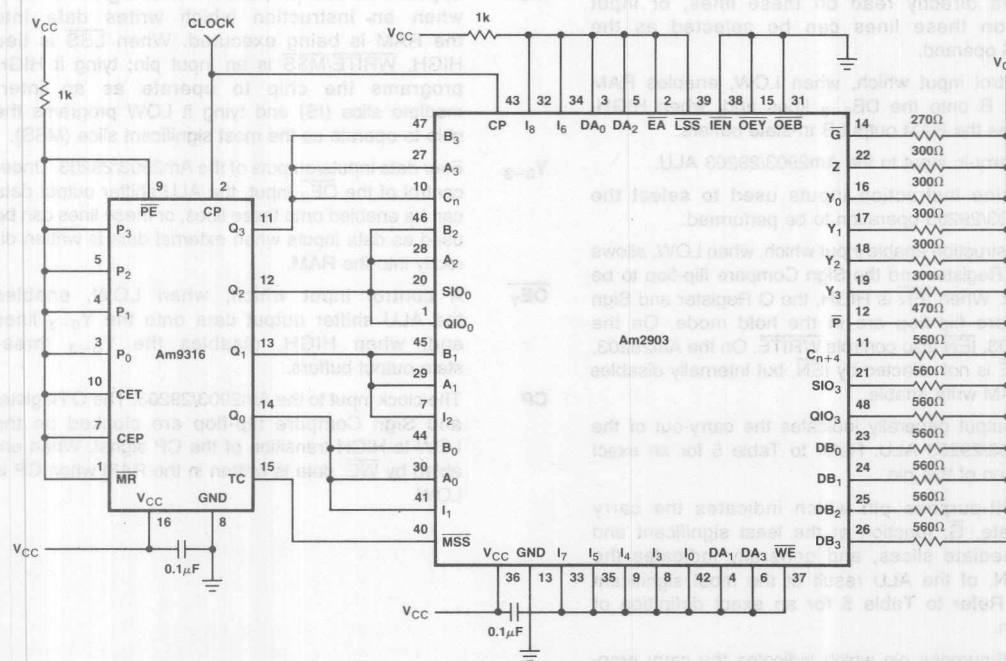
MPR-034

## METALLIZATION AND PAD LAYOUT



DIE SIZE 0.163" X 0.197"

Note: Pin numbers correspond to DIP package.

V<sub>CC</sub> = 5.0V

Frequency = 100kHz

T<sub>A</sub> = +125°C

All registers are 1/4 watt ±5%

This circuit conforms to MIL-STD-883, Methods 1005 and 1015, Condition D.

One Am9316 Can Drive Maximum of Five Am2903s.

MPR-582

## Am2903 Burn-in and Life Test Circuit



## Am2903 • Am29203

**OPERATING RANGES** (over which DC, switching, and functional specifications apply)

| Range | Part Number<br>Suffix      | Temperature                    | V <sub>CC</sub> | V <sub>IH</sub> | V <sub>IL</sub> |
|-------|----------------------------|--------------------------------|-----------------|-----------------|-----------------|
| COM'L | PC, PCB,<br>DC, DCB,<br>XC | T <sub>A</sub> = 0 to 70°C     | 4.75 to 5.25V   | 2.0V            | 0.8V            |
| MIL   | DM, DMB,<br>FM, FMB,<br>XM | T <sub>C</sub> = -55 to +125°C | 4.50 to 5.50V   | 2.0V            | 0.3V            |

2

**ABSOLUTE MAXIMUM RATINGS** (Above which the useful life may be impaired)

|   |                               |
|---|-------------------------------|
| Storage Temperature                                 | -65 to +150°C                 |
| Temperature (Ambient) Under Bias                    | -55 to +125°C                 |
| Supply Voltage to Ground Potential Continuous       | -0.5 to +7.0V                 |
| DC Voltage Applied to Outputs for High Output State | -0.5 to +V <sub>CC</sub> max. |
| DC Input Voltage                                    | -0.5 to +5.5V                 |
| DC Output Current, Into Outputs                     | 30mA                          |
| DC Input Current                                    | -30 to +5.0mA                 |

**ORDERING INFORMATION**

Order the part number according to the table below to obtain the desired package, temperature range, and screening level.

| Am29203<br>Order<br>Number | Am2903<br>Order<br>Number | Package Type<br>(Note 1) | Operating Range<br>(Note 2) | Screening Level<br>(Note 3)                          |
|----------------------------|---------------------------|--------------------------|-----------------------------|--|
| AM29203DC                  | AM2903DC                  | D-48                     | C                           | C-1  |
| AM29203DC-B                | AM2903DC-B                | D-48                     | C                           | B-2 (Note 4)   |
| AM29203DM                  | AM2903DM                  | D-48                     | M                           | C-3  |
| AM29203DMB                 | AM2903DM-B                | D-48                     | M                           | B-3  |
| AM29203FM                  | AM2903FM                  | F-48                     | M                           | C-3  |
| AM29203FMB                 | AM2903FM-B                | F-48                     | M                           | B-3  |
| AM29203XC                  | AM2903XC                  | Dice                     | C                           | Visual inspection<br>to MIL-STD-883<br>Method 2010B. |
| AM29203XM                  | AM2903XM                  | Dice                     | M                           |  |

Notes: 1. P = Molded DIP, D = Hermetic DIP, F = Flat Pak. Number following letter is number of leads. See Appendix B for detailed outline.

Where Appendix B contains several dash numbers, any of the variations of the package may be used unless otherwise specified.

2. C = 0°C to +70°C, V<sub>CC</sub> = 4.75V to 5.25V, M = -55°C to +125°C, V<sub>CC</sub> = 4.50V to 5.50V.

3. See Appendix A for details of screening. Levels C-1 and C-3 conform to MIL-STD-883, Class C. Level B-3 conforms to MIL-STD-883, Class B.

4. 96 hour burn-in.

|  |   |  |  |                                |     |       |       |    |
|--|---|--|--|--------------------------------|-----|-------|-------|----|
| V <sub>OH</sub>  | Output HIGH Voltage                             | V <sub>CC</sub> = MIN.<br>V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>                         | I <sub>OH</sub> = -1.6mA<br>Y <sub>0</sub> -Y <sub>3</sub> , $\overline{G}/N$  |                                | 2.4 | Volts |       |    |
|  |   |  | I <sub>OH</sub> = -800μA<br>DB <sub>0-3</sub> , $\overline{P}/OVR$<br>SIO <sub>0</sub> , SIO <sub>3</sub> , QIO <sub>0</sub> , QIO <sub>3</sub> ,<br>WRITE, C <sub>n+4</sub> |                                | 2.4 |       |       |    |
| I <sub>CEX</sub>   | Output Leakage Current<br>for Z Output (Note 4) | V <sub>CC</sub> = MIN., V <sub>OH</sub> = 5.5V<br>V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub> |  |                                |     | 250   | μA    |    |
| V <sub>OL</sub>  | Output LOW Voltage                              | V <sub>CC</sub> = MIN.<br>V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>                         | Y <sub>0</sub> , Y <sub>1</sub> , Y <sub>2</sub><br>Y <sub>3</sub> , Z   | I <sub>OL</sub> = 20mA (COM'L) |     | 0.5   | Volts |    |
|  |   |  |  | I <sub>OL</sub> = 16mA (MIL)   |     |       |       |    |
|  |   |  | DB <sub>0</sub> , DB <sub>1</sub> ,<br>DB <sub>2</sub> , DB <sub>3</sub>   | I <sub>OL</sub> = 12mA (COM'L) |     | 0.5   |       |    |
|  |   |  |  | I <sub>OL</sub> = 8.0mA (MIL)  |     |       |       |    |
|  |   |  | $\overline{G}/N$   | I <sub>OL</sub> = 18mA         |     | 0.5   |       |    |
|  |   |  | $\overline{P}/OVR$   | I <sub>OL</sub> = 10mA         |     | 0.5   |       |    |
| C <sub>n+4</sub> , SIO <sub>0</sub><br>SIO <sub>3</sub> , QIO <sub>0</sub><br>QIO <sub>3</sub> , WRITE | I <sub>OL</sub> = 8.0mA                         |  | 0.5  |                                |     |       |       |    |
| V <sub>IH</sub>  | Input HIGH Level                                | Guaranteed input logical HIGH<br>voltage for all inputs (Note 6)                                       |  |                                |     | 2.0   | Volts |    |
| V <sub>IL</sub>  | Input LOW Level                                 | Guaranteed input logical LOW<br>voltage for all inputs (Note 6)  |  |                                |     | 0.8   | Volts |    |
| V <sub>I</sub>   | Input Clamp Voltage                             | V <sub>CC</sub> = MIN., I <sub>IN</sub> = -18mA  |  |                                |     | -1.5  | Volts |    |
| I <sub>IL</sub>  | Input LOW Current                               | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 0.5V<br>(Note 4)   | C <sub>n</sub>   |                                |     | -3.6  | mA    |    |
|  |   |  | Y <sub>0</sub> , Y <sub>1</sub> , Y <sub>2</sub> , Y <sub>3</sub>  |                                |     | -1.13 |       |    |
|  |   |  | I <sub>0</sub> , I <sub>1</sub> , I <sub>2</sub> , I <sub>3</sub> , I <sub>4</sub><br>DA <sub>0</sub> , DA <sub>1</sub> , DA <sub>2</sub> , DA <sub>3</sub>                  |                                |     | -0.72 |       |    |
|  |   |  | SIO <sub>0</sub> , SIO <sub>3</sub> , QIO <sub>0</sub> ,<br>QIO <sub>3</sub> , MSS, DB <sub>0</sub> , DB <sub>1</sub> ,<br>DB <sub>2</sub> , DB <sub>3</sub>                 |                                |     | -0.77 |       |    |
|  |   |  | All other inputs   |                                |     | -0.36 |       |    |
| I <sub>IH</sub>  | Input HIGH Current                              | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 2.7V<br>(Note 4)   | C <sub>n</sub>   |                                |     | 200   | μA    |    |
|  |   |  | Y <sub>0</sub> , Y <sub>1</sub> , Y <sub>2</sub> , Y <sub>3</sub>  |                                |     | 110   |       |    |
|  |   |  | I <sub>0</sub> -I <sub>4</sub> , DA <sub>0</sub> -DA <sub>3</sub>  |                                |     | 40    |       |    |
|  |   |  | SIO <sub>0</sub> , SIO <sub>3</sub> , QIO <sub>0</sub> ,<br>QIO <sub>3</sub> , DB <sub>0-3</sub> ,<br>MSS  |                                |     | 90    |       |    |
|  |   |  | All other inputs   |                                |     | 20    |       |    |
| I <sub>I</sub>   | Input HIGH Current                              | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 5.5V   |  |                                |     | 1.0   | mA    |    |
| I <sub>OZH</sub><br>I <sub>OZL</sub>   | Off State<br>(HIGH Impedance)<br>Output Current | V <sub>CC</sub> = MAX.,<br>(Note 4)  | Y <sub>0</sub> -Y <sub>3</sub>   | V <sub>O</sub> = 2.4V          |     | 110   | μA    |    |
|  |   |  |  | V <sub>O</sub> = 0.5V          |     | -1130 |       |    |
|  |   |  | DB <sub>0-3</sub> , QIO <sub>0</sub> , QIO <sub>3</sub> ,<br>SIO <sub>0</sub> , SIO <sub>3</sub> , MSS/IS  | V <sub>O</sub> = 2.4V          |     | 90    |       |    |
|  |   |  |  | V <sub>O</sub> = 0.5V          |     | -770  |       |    |
| I <sub>OS</sub>  | Output Short Circuit<br>Current (Note 3)        | V <sub>CC</sub> = MAX + 0.5V<br>V <sub>O</sub> = 0.5V  |  |                                |     | -30   | -85   | mA |
| I <sub>CC</sub>  | Power Supply Current<br>(Note 5)                | V <sub>CC</sub> = MAX.   | T <sub>A</sub> = 25°C  |                                |     | 220   | 335   | mA |
|  |   |  | COM'L  | T <sub>A</sub> = 0 to 70°C     |     |       | 350   |    |
|  |   |  |  | T <sub>A</sub> = 70°C          |     |       | 291   |    |
|  |   |  | MIL  | T <sub>C</sub> = -55 to 125°C  |     |       | 395   |    |
|  |   |  |  | T <sub>C</sub> = 125°C         |     |       | 258   |    |

- Notes: 1. For conditions shown as MIN. or MAX., use the appropriate value specified under Electrical Characteristics for the applicable device type.  
2. Typical limits are at V<sub>CC</sub> = 5.0V, 25°C ambient and maximum loading.  
3. Not more than one output should be shorted at a time. Duration of the short circuit test should not exceed one second.  
4. Y<sub>0-3</sub>, DB<sub>0-3</sub>, SIO<sub>0,3</sub>, QIO<sub>0,3</sub> and WRITE/MSS are three state outputs internally connected to TTL inputs. Z is an open-collector output internally connected to a TTL input. Input characteristics are measured under conditions such that the outputs are in the OFF state.  
5. Worst case I<sub>CC</sub> is at minimum temperature.  
6. These input levels provide zero noise immunity and should only be tested in a static, noise-free environment.

## Am2903 SWITCHING CHARACTERISTICS

Am2903 switching characteristics are dependent on temperature, voltage, and the operating mode of the device. The detailed data for the part is given in the 24 tables comprising Appendix A

of this data sheet. For reference, one set of these tables is reproduced on this page and the next. For switching data for special functions and military devices, refer to Appendix A.

**TABLE III A**  
Guaranteed Combinational Delays  
 $T_A = 0^\circ\text{C to } +70^\circ\text{C}$ ,  $V_{CC} = 4.75\text{V to } 5.25\text{V}$   
Standard Functions

| From Input \ To Output       | Y  | $C_{n+4}$ | $\bar{G}, \bar{P}$ | Z (s) | N  | OVR | DB | WRITE | $\text{QIO}_0$<br>$\text{QIO}_3$ | $\text{SIO}_0$ | $\text{SIO}_3$ | $\text{SIO}_0$<br>Parity |
|------------------------------|----|-----------|--------------------|-------|----|-----|----|-------|----------------------------------|----------------|----------------|--------------------------|
| A Address (Arith. Mode)      | 86 | 81        | 69                 | 110   | 86 | 108 | —  | —     | —                                | 84             | 94             | 115                      |
| B Address                    | 99 | 88        | 81                 | 123   | 99 | 112 | 49 | —     | —                                | 94             | 104            | 140                      |
| A Address (Logic Mode)       | 87 | —         | 68                 | 111   | 89 | —   | —  | —     | —                                | 79             | 94             | 115                      |
| B Address                    | 84 | —         | 73                 | 108   | 84 | —   | 49 | —     | —                                | 84             | 90             | 120                      |
| DA Inputs (Arith. Mode)      | 63 | 60        | 49                 | 87    | 64 | 89  | —  | —     | —                                | 60             | 70             | 101                      |
| DB Inputs                    | 61 | 59        | 47                 | 85    | 62 | 84  | —  | —     | —                                | 62             | 68             | 98                       |
| DA Inputs (Logic Mode)       | 64 | —         | 48                 | 88    | 66 | —   | —  | —     | —                                | 61             | 72             | 101                      |
| DB Inputs                    | 55 | —         | 32                 | 79    | 57 | —   | —  | —     | —                                | 52             | 61             | 93                       |
| $\bar{E}A$                   | 59 | 53        | 42                 | 83    | 59 | 83  | —  | —     | —                                | 57             | 64             | 98                       |
| $C_n$                        | 40 | 30        | —                  | 64    | 40 | 58  | —  | —     | —                                | 38             | 46             | 67                       |
| $I_0$                        | 52 | 48        | 36                 | 76    | 52 | 63  | —  | 49    | *                                | 50*            | 58*            | 93*                      |
| $I_{4321}$                   | 71 | 65        | 72                 | 95    | 69 | 84  | —  | 49    | *                                | 66*            | 73*            | 105*                     |
| $I_{8765}$                   | 42 | —         | —                  | 66    | —  | —   | —  | 50    | 60*                              | 42*            | 45*            | 42*                      |
| $\bar{I}EN$                  | —  | —         | —                  | —     | —  | —   | —  | 22    | —                                | —              | —              | —                        |
| $\text{SIO}_3, \text{SIO}_0$ | 26 | —         | —                  | 50    | —  | —   | —  | —     | —                                | —              | 29             | 36                       |
| Clock                        | 87 | 87        | 71                 | 111   | 88 | 108 | 37 | —     | 40                               | 84             | 92             | 105                      |
| Y                            | —  | —         | —                  | 24    | —  | —   | —  | —     | —                                | —              | —              | —                        |
| $\overline{\text{MSS}}$      | 44 | —         | 44                 | 68    | 44 | 44  | —  | —     | —                                | 44             | 46             | 44                       |

Note: A "\*" means the output is enabled or disabled by the input. See Tables C for enable and disable times. A number shown with a \* is the delay to correct data on an enabled output. A \* shown without a number means the output is disabled by the input or it is enabled but the delay to correct data is determined by something else.

**TABLE III B**  
**Guaranteed Set-up and Hold Times**  
 $T_A = 0^\circ\text{C to } +70^\circ\text{C}$ ,  $V_{CC} = 4.75\text{V to } 5.25\text{V}$   
**All Functions**

**CAUTION: READ NOTES TO TABLE B. NA = Not Applicable; no timing constraint.**

| To Output<br>From Input             | With Respect<br>to this Signal | HIGH-to-LOW |        | LOW-to-HIGH |      | Comment  |
|-------------------------------------|--------------------------------|-------------|--------|-------------|------|--|
|                                     |                                | Set-up      | Hold   | Set-up      | Hold |  |
| Y                                   | Clock                          | NA          | NA     | 20          | 3    | To store Y in RAM or Q                           |
| WE HIGH                             | Clock                          | 25          | Note 2 | Note 2      | 0    | To Prevent Writing                               |
| WE LOW                              | Clock                          | NA          | NA     | 30          | 0    | To Write into RAM                                |
| A, B as Sources                     | Clock                          | 27          | 3      | NA          | NA   | See Note 3                                       |
| B as a Destination                  | Clock and WE both LOW          | 6           | Note 4 | Note 4      | 3    | To Write Data only into<br>the Correct B Address |
| QIO <sub>0</sub> , QIO <sub>3</sub> | Clock                          | NA          | NA     | 21          | 3    | To Shift Q                                       |
| I <sub>8765</sub>                   | Clock                          | 24          | Note 5 | Note 5      | 0    |  |
| IEN HIGH                            | Clock                          | 30          | Note 2 | Note 2      | 0    | To Prevent Writing into Q                        |
| IEN LOW                             | Clock                          | NA          | NA     | 30          | 0    | To Write into Q                                  |
| I <sub>43210</sub>                  | Clock                          | 24          | —      | 68          | 0    | See Note 6                                       |

**Notes:**

- For set-up times from all inputs not specified in Table B, the set-up time is computed by calculating the delay to stable Y outputs and then allowing the Y set-up time. Even if the RAM is not being loaded, the Y set-up time is necessary to set-up the Q register. All unspecified hold times are less than or equal to zero relative to the clock LOW-to-HIGH edge.
- WE controls writing into the RAM. IEN controls writing into Q and, indirectly, controls WE through the write output. To prevent writing, IEN and WE must be HIGH during the entire clock LOW time. They may go LOW after the clock has gone LOW to cause a write provided the WE LOW and IEN LOW set-up times are met. Having gone LOW, they should not be returned HIGH until after the clock has gone HIGH.
- A and B addresses must be set-up prior to clock LOW transition to capture data in latches at RAM output.
- Writing occurs when CP and WE are both LOW. The B address should be stable during this entire period.
- Because I<sub>8765</sub> control the writing or not writing of data into RAM and Q, they should be stable during the entire clock LOW time unless IEN is HIGH, preventing writing.
- The set-up time prior to the clock LOW-to-HIGH transition occurs in parallel with the set-up time prior to the clock HIGH-to-LOW transition and the clock LOW time. The actual set-up time requirement on I<sub>43210</sub>, relative to the clock LOW-to-HIGH transition, is the longer of (1) the set-up time prior to clock L → H, and (2) the sum of the set-up time prior to clock H → L and the clock LOW time.

**TABLE III C**  
**Guaranteed Enable/Disable Times**  
 $T_A = 0^\circ\text{C to } +70^\circ\text{C}$ ,  $V_{CC} = 4.75\text{V to } 5.25\text{V}$   
**All Functions**

| From               | To                                  | Enable | Disable |    |
|--------------------|-------------------------------------|--------|---------|----|
| OEY                | Y <sub>i</sub>                      | 27     | 25      | ns |
| OEB                | DB <sub>i</sub>                     | 31     | 25      | ns |
| I <sub>8</sub>     | SIO <sub>0</sub> , SIO <sub>3</sub> |        | 25      | ns |
| I <sub>8765</sub>  | QIO <sub>0</sub> , QIO <sub>3</sub> |        | 60      | ns |
| I <sub>43210</sub> | QIO <sub>0</sub> , QIO <sub>3</sub> | 65     | 60      | ns |
| LSS                | WRITE                               | 31     | 25      | ns |

**Note:**

- $C_L = 5.0\text{pF}$  for output disable tests. Measurement is made to a 0.5V change on the output.

**TABLE III D**  
**Guaranteed Clock and Write Pulse Characteristics**  
 $T_A = 0^\circ\text{C to } +70^\circ\text{C}$ ,  $V_{CC} = 4.75\text{V to } 5.25\text{V}$   
**All Functions**

|  |    |    |
|--|----|----|
| Minimum Clock LOW Time                   | 30 | ns |
| Minimum Clock HIGH Time                  | 30 | ns |
| Minimum Time CP and WE both LOW to Write | 30 | ns |



The maximum time required to obtain valid Y outputs after a clock LOW-TO-HIGH transition.

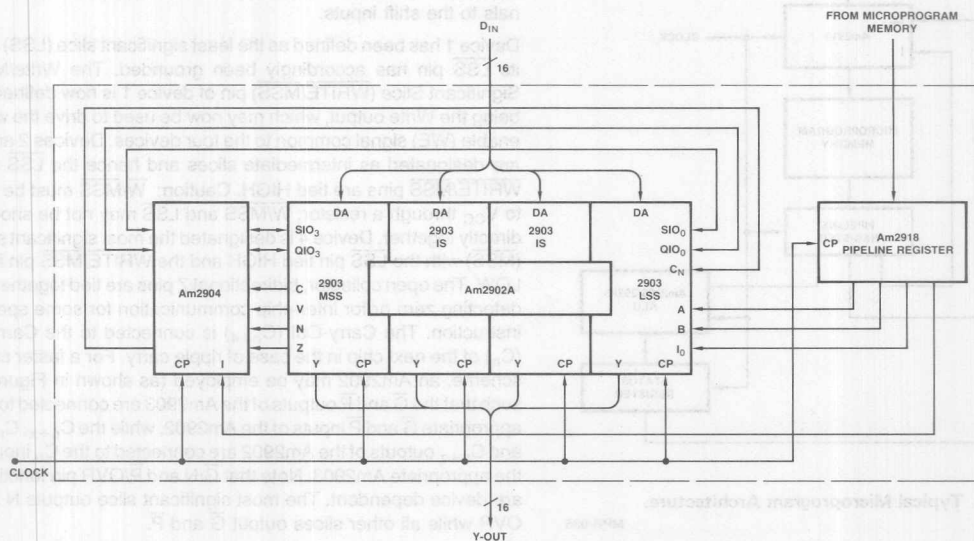
The types of cycles for which data is summarized are as follows:

- The maximum time required to obtain valid Y output data after the D inputs are valid. This is the combinational delay through the parts from D to Y.

1. Logic – Any logical operation without a shift.
2. Logic Rotate – Any logic operation with a rotate or shift.
3. Arithmetic – An add or subtract with no shift.
4. Multiply – The first cycle of a 2's complement multiply instruction. Subsequent cycles require less time.
5. Divide – The iterative divide cycle. The first divide instruction and the last divide (correction) instruction require less time.

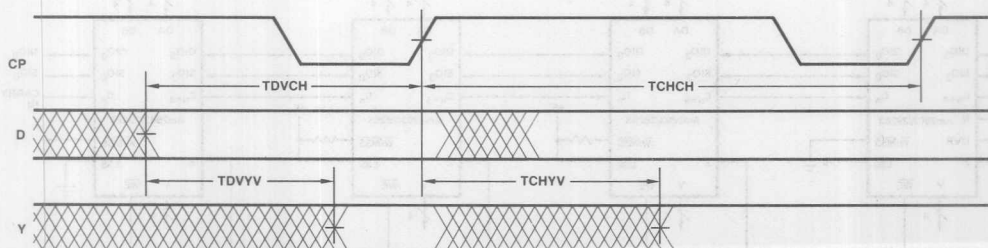
| CYCLE | TCHCH | TDVCH | TDVYV | TCHYV |
|-------|-------|-------|-------|-------|
| 1     | 1     | 1     | 1     | 1     |
| 2     | 1     | 1     | 1     | 1     |
| 3     | 1     | 1     | 1     | 1     |
| 4     | 1     | 1     | 1     | 1     |
| 5     | 1     | 1     | 1     | 1     |
| 6     | 1     | 1     | 1     | 1     |
| 7     | 1     | 1     | 1     | 1     |
| 8     | 1     | 1     | 1     | 1     |
| 9     | 1     | 1     | 1     | 1     |
| 10    | 1     | 1     | 1     | 1     |
| 11    | 1     | 1     | 1     | 1     |
| 12    | 1     | 1     | 1     | 1     |
| 13    | 1     | 1     | 1     | 1     |
| 14    | 1     | 1     | 1     | 1     |
| 15    | 1     | 1     | 1     | 1     |
| 16    | 1     | 1     | 1     | 1     |
| 17    | 1     | 1     | 1     | 1     |
| 18    | 1     | 1     | 1     | 1     |
| 19    | 1     | 1     | 1     | 1     |
| 20    | 1     | 1     | 1     | 1     |
| 21    | 1     | 1     | 1     | 1     |
| 22    | 1     | 1     | 1     | 1     |
| 23    | 1     | 1     | 1     | 1     |
| 24    | 1     | 1     | 1     | 1     |
| 25    | 1     | 1     | 1     | 1     |
| 26    | 1     | 1     | 1     | 1     |
| 27    | 1     | 1     | 1     | 1     |
| 28    | 1     | 1     | 1     | 1     |
| 29    | 1     | 1     | 1     | 1     |
| 30    | 1     | 1     | 1     | 1     |
| 31    | 1     | 1     | 1     | 1     |
| 32    | 1     | 1     | 1     | 1     |
| 33    | 1     | 1     | 1     | 1     |
| 34    | 1     | 1     | 1     | 1     |
| 35    | 1     | 1     | 1     | 1     |
| 36    | 1     | 1     | 1     | 1     |
| 37    | 1     | 1     | 1     | 1     |
| 38    | 1     | 1     | 1     | 1     |
| 39    | 1     | 1     | 1     | 1     |
| 40    | 1     | 1     | 1     | 1     |
| 41    | 1     | 1     | 1     | 1     |
| 42    | 1     | 1     | 1     | 1     |
| 43    | 1     | 1     | 1     | 1     |
| 44    | 1     | 1     | 1     | 1     |
| 45    | 1     | 1     | 1     | 1     |
| 46    | 1     | 1     | 1     | 1     |
| 47    | 1     | 1     | 1     | 1     |
| 48    | 1     | 1     | 1     | 1     |
| 49    | 1     | 1     | 1     | 1     |
| 50    | 1     | 1     | 1     | 1     |
| 51    | 1     | 1     | 1     | 1     |
| 52    | 1     | 1     | 1     | 1     |
| 53    | 1     | 1     | 1     | 1     |
| 54    | 1     | 1     | 1     | 1     |
| 55    | 1     | 1     | 1     | 1     |
| 56    | 1     | 1     | 1     | 1     |
| 57    | 1     | 1     | 1     | 1     |
| 58    | 1     | 1     | 1     | 1     |
| 59    | 1     | 1     | 1     | 1     |
| 60    | 1     | 1     | 1     | 1     |
| 61    | 1     | 1     | 1     | 1     |
| 62    | 1     | 1     | 1     | 1     |
| 63    | 1     | 1     | 1     | 1     |
| 64    | 1     | 1     | 1     | 1     |
| 65    | 1     | 1     | 1     | 1     |
| 66    | 1     | 1     | 1     | 1     |
| 67    | 1     | 1     | 1     | 1     |
| 68    | 1     | 1     | 1     | 1     |
| 69    | 1     | 1     | 1     | 1     |
| 70    | 1     | 1     | 1     | 1     |
| 71    | 1     | 1     | 1     | 1     |
| 72    | 1     | 1     | 1     | 1     |
| 73    | 1     | 1     | 1     | 1     |
| 74    | 1     | 1     | 1     | 1     |
| 75    | 1     | 1     | 1     | 1     |
| 76    | 1     | 1     | 1     | 1     |
| 77    | 1     | 1     | 1     | 1     |
| 78    | 1     | 1     | 1     | 1     |
| 79    | 1     | 1     | 1     | 1     |
| 80    | 1     | 1     | 1     | 1     |
| 81    | 1     | 1     | 1     | 1     |
| 82    | 1     | 1     | 1     | 1     |
| 83    | 1     | 1     | 1     | 1     |
| 84    | 1     | 1     | 1     | 1     |
| 85    | 1     | 1     | 1     | 1     |
| 86    | 1     | 1     | 1     | 1     |
| 87    | 1     | 1     | 1     | 1     |
| 88    | 1     | 1     | 1     | 1     |
| 89    | 1     | 1     | 1     | 1     |
| 90    | 1     | 1     | 1     | 1     |
| 91    | 1     | 1     | 1     | 1     |
| 92    | 1     | 1     | 1     | 1     |
| 93    | 1     | 1     | 1     | 1     |
| 94    | 1     | 1     | 1     | 1     |

|              |     |     |     |     |
|--------------|-----|-----|-----|-----|
| LOGIC        | 143 | 105 | 64  | 102 |
| LOGIC ROTATE | 180 | 143 | 123 | 160 |
| ARITHMETIC   | 184 | 137 | 96  | 143 |
| MULTIPLY     | 200 | 140 | 120 | 180 |
| DIVIDE       | 228 | 167 | 128 | 189 |



### 16-Bit System with Am2903, Am2902A, Am2904

MPR-583



### Timing Waveforms for Data In, Clock, and Y Out

MPR-584

## Am2903 APPLICATIONS

The Am2903 is designed to be used in microprogrammed systems. Figure 1 illustrates a recommended architecture. The control and data inputs to the Am2903 normally will all come from registers clocked at the same time as the Am2903. The register inputs come from a ROM or PROM — the "microprogram store". This memory contains sequences of microinstructions which apply the proper control signals to the Am2903's and other circuits to execute the desired operation.

The address lines of the microprogram store are driven from the Am2910 Microprogram Sequencer. This device has facilities for storing an address, incrementing an address, jumping to any address, and linking subroutines. The Am2910 is controlled by some of the bits coming from the microprogram store. Essentially, these bits are the "next instruction" control.

One Level Pipeline Based System

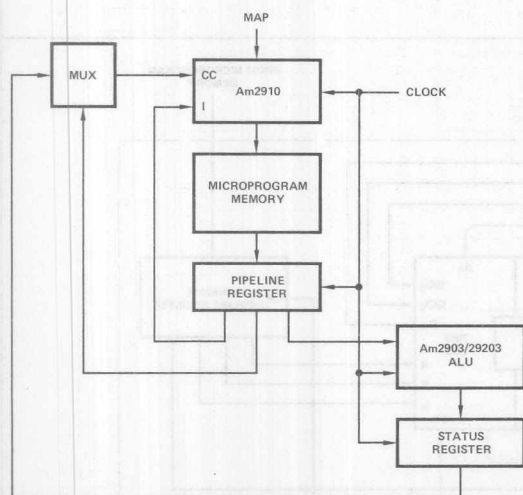


Figure 1. Typical Microprogram Architecture.

MPR-035

microinstruction is executed, the next microinstruction is being read from microprogram memory. In this configuration, system speed is improved because the execution time in the Am2903's occurs in parallel with the access time of the microprogram store. Without the "pipeline register", these two functions must occur serially.

## Expansion of the Am2903

The Am2903 is a four-bit CPU slice. Any number of Am2903's can be interconnected to form CPU's of 8, 16, 32, or more bits, in four-bit increments. Figure 2 illustrates the interconnection of four Am2903's to form a 16-bit CPU, using ripple carry.

With the exception of the carry interconnection, all expansion schemes are the same. The  $QIO_3$  and  $SIO_3$  pins are bidirectional left/right shift lines at the MSB of the device. For all devices except the most significant, these lines are connected to the  $QIO_0$  and  $SIO_0$  pins of the adjacent more significant device. These connections allow the Q Registers of all Am2903's to be shifted left or right as a contiguous n-bit register, and also allow the ALU output data to be shifted left or right as a contiguous n-bit word prior to storage in the RAM. At the LSB and MSB of the CPU, the shift pins should be connected to a shift multiplexer which can be controlled by the microcode to select the appropriate input signals to the shift inputs.

Device 1 has been defined as the least significant slice (LSS) and its  $\overline{LSS}$  pin has accordingly been grounded. The Write/Most Significant Slice ( $\overline{WRITE/MSS}$ ) pin of device 1 is now defined as being the Write output, which may now be used to drive the write enable ( $\overline{WE}$ ) signal common to the four devices. Devices 2 and 3 are designated as intermediate slices and hence the  $\overline{LSS}$  and  $\overline{WRITE/MSS}$  pins are tied HIGH. Caution:  $\overline{W/MSS}$  must be tied to  $V_{CC}$  through a resistor;  $\overline{W/MSS}$  and  $\overline{LSS}$  may not be shorted directly together. Device 4 is designated the most significant slice (MSS) with the  $\overline{LSS}$  pin tied HIGH and the  $\overline{WRITE/MSS}$  pin held LOW. The open collector, bidirectional Z pins are tied together for detecting zero or for inter-chip communication for some special instruction. The Carry-Out ( $C_{n+4}$ ) is connected to the Carry-In ( $C_n$ ) of the next chip in the case of ripple carry. For a faster carry scheme, an Am2902 may be employed (as shown in Figure 3) such that the  $\overline{G}$  and  $\overline{P}$  outputs of the Am2903 are connected to the appropriate  $\overline{G}$  and  $\overline{P}$  inputs of the Am2902, while the  $C_{n+x}$ ,  $C_{n+y}$ , and  $C_{n+z}$  outputs of the Am2902 are connected to the  $C_n$  input of the appropriate Am2903. Note that  $\overline{G/N}$  and  $\overline{P/OVR}$  pin functions are device dependent. The most significant slice outputs N and OVR while all other slices output  $\overline{G}$  and  $\overline{P}$ .

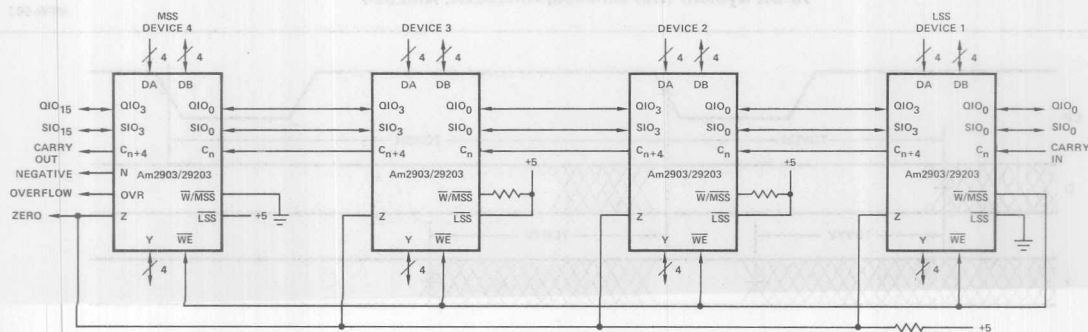


Figure 2. 16-Bit CPU with Ripple Carry.

MPR-036

The  $\overline{\text{IEN}}$  pin of the Am2903 allows the option of conditional instruction execution. If  $\overline{\text{IEN}}$  is LOW, all internal clocking is enabled, allowing the latches, RAM, and Q Register to function. If  $\overline{\text{IEN}}$  is HIGH, the RAM and Q Register are disabled. The RAM is controlled by  $\overline{\text{IEN}}$  if WE is connected to the WRITE output.

It would be appropriate at this point to mention that the Am2903 may be microcoded to work in either two-or three-address architecture modes. The two-address modes allow  $A+B \rightarrow B$  while the three-address mode makes possible  $A+B \rightarrow C$ . Implementation of a three-address architecture is made possible by varying the timing of  $\overline{\text{IEN}}$  in relationship to the external clock and changing the B address as shown in Figure 4. This technique is discussed in more detail under Memory Expansion.

## Parity

The Am2903 computes parity on a chosen word when the instruction bits  $I_{5-8}$  have the values of  $4_{16}$  to  $7_{16}$  as shown in Table 3. The computed parity is the result of the exclusive OR of the individual ALU outputs and  $\text{SIO}_3$ . Parity output is found on  $\text{SIO}_0$ . Parity between devices may be cascaded by the interconnection of the  $\text{SIO}_0$  and  $\text{SIO}_3$  ports of the devices as shown in Figure 3. The equation for the parity output at  $\text{SIO}_0$  port of device 1 is given by  $\text{SIO}_0 = F_{15} \vee F_{14} \vee F_{13} \vee \dots \vee F_1 \vee F_0 \vee \text{SIO}_{15}$ .

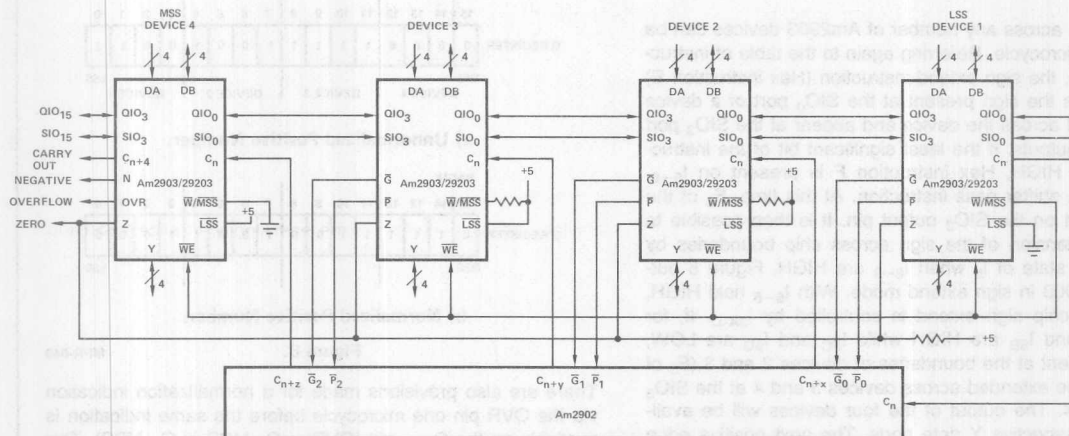


Figure 3. 16-Bit CPU with Carry Look Ahead.

MPR-037

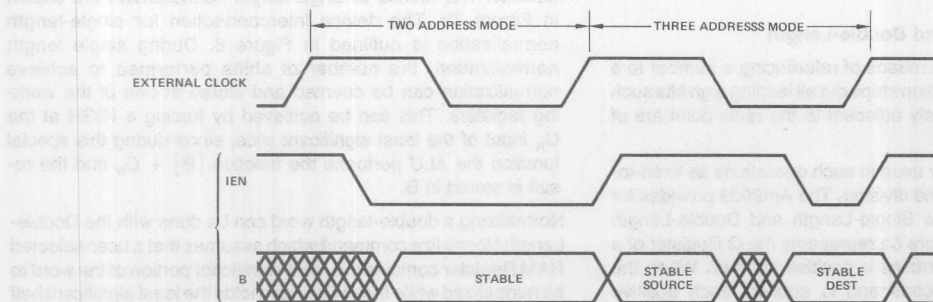


Figure 4. Relationship of  $\overline{\text{IEN}}$  and Clock During Two Address and Three Address Modes.

MPR-038

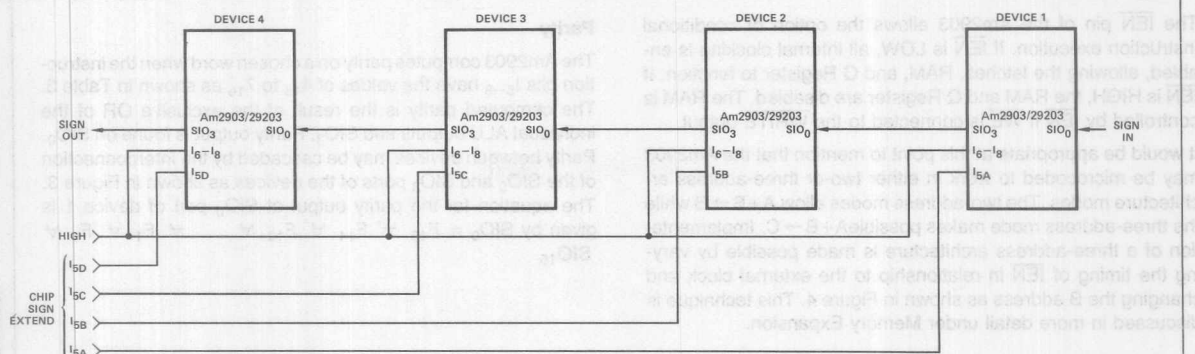


Figure 5. Sign Extend.

MPR-039

### Sign Extend

Sign extension across any number of Am2903 devices can be done in one microcycle. Referring again to the table of instructions (Table 3), the sign extend instruction (Hex instruction E) on  $I_{5-8}$  causes the sign present at the  $SIO_0$  port of a device to be extended across the device and appear at the  $SIO_3$  port and at the Y outputs. If the least significant bit of the instruction (bit  $I_5$ ) is HIGH, Hex instruction F is present on  $I_{5-8}$ , commanding a shifter pass instruction. At this time,  $F_3$  of the ALU is present on the  $SIO_3$  output pin. It is then possible to control the extension of the sign across chip boundaries by controlling the state of  $I_5$  when  $I_{6-8}$  are HIGH. Figure 5 outlines the Am2903 in sign extend mode. With  $I_{6-8}$  held HIGH, the individual chip sign extend is controlled by  $I_{5A-D}$ . If, for example,  $I_{5A}$  and  $I_{5B}$  are HIGH while  $I_{5C}$  and  $I_{5D}$  are LOW, the signal present at the boundaries of devices 2 and 3 ( $F_3$  of device 2) will be extended across devices 3 and 4 at the  $SIO_3$  pin of device 4. The output of the four devices will be available at their respective Y data ports. The next positive edge of the clock will load the Y outputs into the address selected by the B port. Hence, the results of the sign extension is stored in the RAM.

### SPECIAL FUNCTIONS

When  $I_{0-4} = 0$ , the Am2903 is in the Special Function mode. In this mode, both the source and destination are controlled by  $I_{5-8}$ . The Special Functions are in essence special microinstructions that are used to reduce the number of microcycles needed to execute certain functions in the Am2903.

#### Normalization, Single- and Double-Length

Normalization is used as a means of referencing a number to a fixed radix point. Normalization strips out all leading sign bits such that the two bits immediately adjacent to the radix point are of opposite polarity.

Normalization is commonly used in such operations as fixed-to-floating point conversion and division. The Am2903 provides for normalization by using the Single-Length and Double-Length Normalize commands. Figure 6a represents the Q Register of a 16-bit processor which contains a positive number. When the Single-Length Normalize command is applied, each positive edge of the clock will cause the bits to shift toward the most significant bit (bit 15) of the Q Register. Zeros are shifted in via the  $QIO_0$  port. When the bits on either side of the radix point (bits 14 and 15) are of opposite value, the number is considered to be normalized as shown in Figure 6b. The event of normalization is externally indicated by a HIGH level on the  $C_{n+4}$  pin of the most significant slice ( $C_{n+4} \text{ MSS} = Q_3 \text{ MSS} \nabla Q_1 \text{ MSS}$ ).

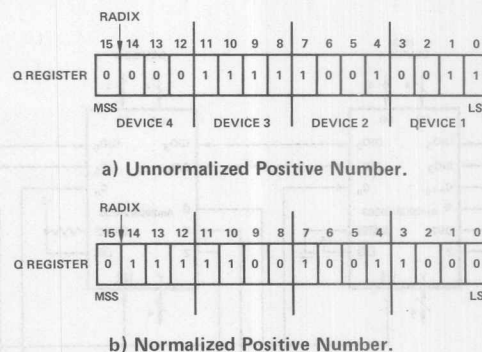


Figure 6.

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There are also provisions made for a normalization indication via the OVR pin one microcycle before the same indication is available on the  $C_{n+4}$  pin ( $OVR = Q_2 \text{ MSS} \nabla Q_1 \text{ MSS}$ ). This is for use in applications that require a stage of register buffering of the normalization indication.

Since a number comprised of all zeros is not considered for normalization, the Am2903 indicates when such a condition arises. If the Q Register is zero and the Single-Length Normalization command is given, a HIGH level will be present on the Z line. The sign output, N, indicates the sign of the number stored in the Q register,  $Q_3 \text{ MSS}$ . An unnormalized negative number (Figure 7a) is normalized in the same manner as a positive number. The results of single-length normalization are shown in Figure 7b. The device interconnection for single-length normalization is outlined in Figure 8. During single length normalization, the number of shifts performed to achieve normalization can be counted and stored in one of the working registers. This can be achieved by forcing a HIGH at the  $C_n$  input of the least significant slice, since during this special function the ALU performs the function  $[B] + C_n$  and the result is stored in B.

Normalizing a double-length word can be done with the Double-Length Normalize command which assumes that a user-selected RAM Register contains the most significant portion of the word to be normalized while the Q Register holds the least significant half (Figure 9). The device interconnection for double-length normalization is shown in Figure 10. The  $C_{n+4}$ , OVR, N, and Z outputs of the most significant slice perform the same functions in double-length normalization as they did in single-length normalization except that  $C_{n+4}$ , OVR, and N are derived from the output of the ALU of the most significant slice in the case of double-length normalization, instead of the Q Register of the most significant



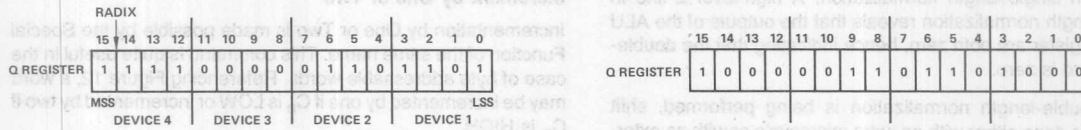


Figure 7.

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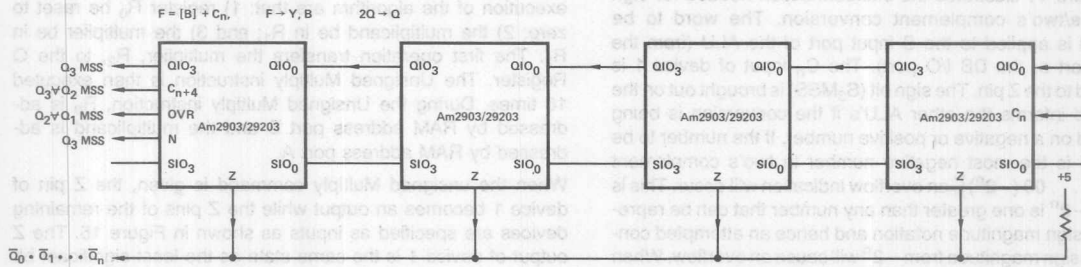


Figure 8. Single Length Normalize.

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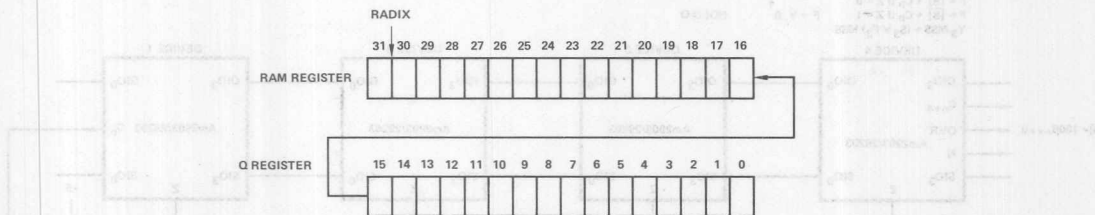


Figure 9. Double Length Word.

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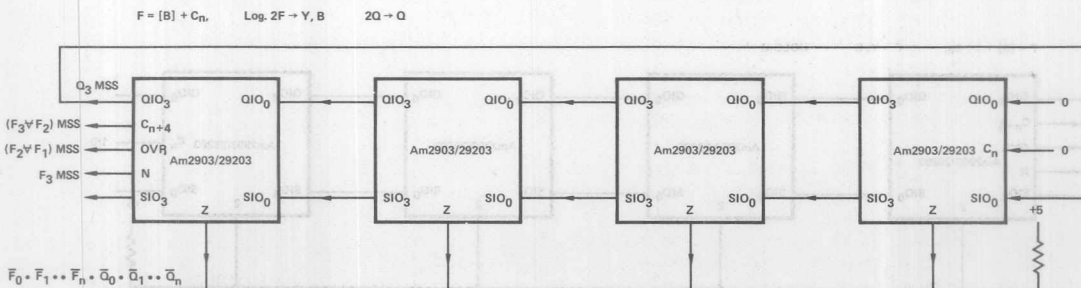


Figure 10. Double Length Normalize.

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slice as in single-length normalization. A high-level Z line in double-length normalization reveals that the outputs of the ALU and Q Register are both zero, hence indicating that the double-length word is zero.

When double-length normalization is being performed, shift counting is done either with an extra microcycle or with an external counter.

### Sign Magnitude, Two's Complement Conversion

As part of the special instruction set, the Am2903 can convert between two's complement and sign/magnitude representations. Figure 11 illustrates the interconnection needed for sign magnitude/two's complement conversion. The word to be converted is applied to the S input port of the ALU (from the RAM B port or the DB I/O port). The  $C_n$  input of device 1 is connected to the Z pin. The sign bit ( $S_3$  MSS) is brought out on the Z line and informs the other ALU's if the conversion is being performed on a negative or positive number. If the number to be converted is the most negative number in two's complement [i.e.,  $100 \dots 00 (-2^n)$ ], an overflow indication will occur. This is because  $-2^n$  is one greater than any number that can be represented in sign magnitude notation and hence an attempted conversion to sign magnitude from  $-2^n$  will cause an overflow. When minus zero in sign magnitude notation ( $100 \dots 0$ ) is converted to two's complement notation, the correct result is obtained ( $0 \dots 0$ ).

### Increment by One or Two

Incrementation by One or Two is made possible by the Special Function of the same name. This command is quite useful in the case of byte addressable words. Referencing Figure 12, a word may be incremented by one if  $C_n$  is LOW or incremented by two if  $C_n$  is HIGH.

### Unsigned Multiply

This Special Function allows for easy implementation of unsigned multiplication. Figure 13 is the unsigned multiply flow chart. The algorithm requires that initially the RAM word addressed by Address port B be zero, that the multiplier be in the Q Register, and that the multiplicand be in the register addressed by Address port A. The initial conditions for the execution of the algorithm are that: 1) register  $R_0$  be reset to zero; 2) the multiplicand be in  $R_1$ ; and 3) the multiplier be in  $R_2$ . The first operation transfers the multiplier,  $R_2$ , to the Q Register. The Unsigned Multiply instruction is then executed 16 times. During the Unsigned Multiply instruction,  $R_0$  is addressed by RAM address port B and the multiplicand is addressed by RAM address port A.

When the unsigned Multiply command is given, the Z pin of device 1 becomes an output while the Z pins of the remaining devices are specified as inputs as shown in Figure 15. The Z output of device 1 is the same state as the least significant bit of the multiplier in the Q Register. The Z output of device 1 informs the ALU's of all the slices, via their Z pins, to add the partial product (referenced by the B address port) to the mul-

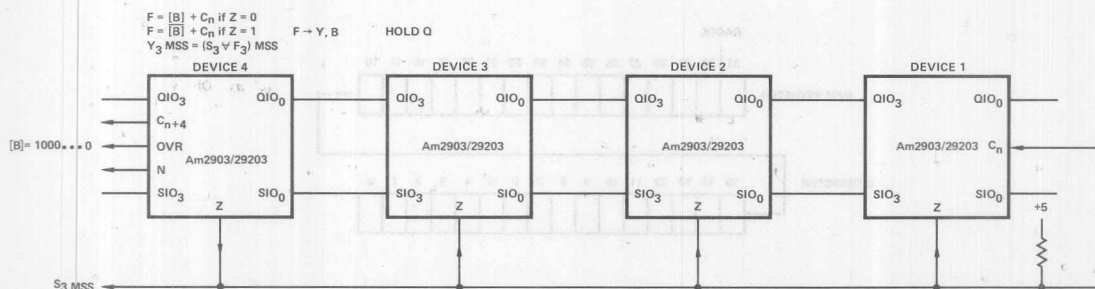


Figure 11. 2's Complement  $\leftrightarrow$  Sign/Magnitude.

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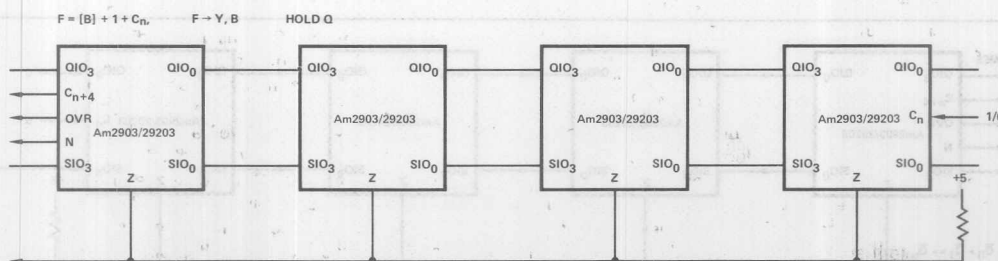


Figure 12. Increment by 2/1.

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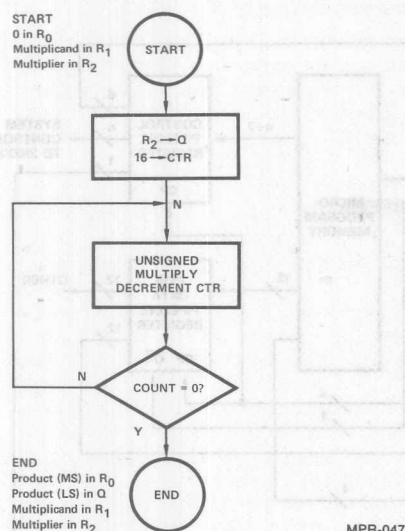


Figure 13. Unsigned 16 X 16 Multiply Flowchart.

tipicand (referenced by the A address port) if  $Z = 1$ . If  $Z = 0$ , the output of the ALU is simply the partial product (referenced by the B address port). Since  $C_n$  is held LOW, it is not a factor in the computation. Each positive-going edge of the clock will internally shift the ALU outputs toward the least significant bit and simultaneously store the shifted results in the register selected by the B address port, thus becoming the new partial sum. During the down shifting process, the  $C_{n+4}$  generated in device 4 is internally shifted into the  $Y_3$  position of device 4. At this time, one bit of the multiplier will down shift out of the  $QIO_0$  ports of each device into the  $QIO_3$  port of the next less significant slice. The partial product is shifted down between chips in a like manner, between the  $SIO_0$  and  $SIO_3$  ports, with  $SIO_0$  of device 1 being connected to  $QIO_3$  of device 4 for purposes of constructing a 32-bit long register to hold the 32-bit product. At the finish of the 16 x 16 multiply, the most significant 16 bits of the product will be found in the register referenced by the B address lines while the least significant 16 bits are stored in the Q Register. Using a typical Computer Control Unit (CCU), as shown in Figure 16, the unsigned multiply operation requires only two lines of microcode, as shown in Figure 17, and is executed in 17 microcycles.

## Two's Complement Multiplication

The algorithm for two's complement multiplication is illustrated by Figure 14. The initial conditions for two's complement multiplication are the same as for the unsigned multiply operation. The Two's Complement Multiply Command is applied for 15 clock cycles in the case of a 16 x 16 multiply. During the down shifting process the term  $N\overline{V}OVR$  generated in device 4 is internally shifted into the  $Y_3$  position of device 4. The data flow shown in Figure 15 is still valid. After 15 cycles, the sign bit of the multiplier is present at the Z output of device 1. At this time, the user must place the Two's Complement Multiply Last cycle command on the instruction lines. The interconnection for this instruction is shown in Figure 18. On the next positive edge of the clock, the Am2903 will adjust the partial product, if the sign of the multiplier is negative, by subtracting out the two's complement representation of the multiplicand. If the sign bit is positive, the partial product is not adjusted. At this point, two's complement multiplication is completed. Using a typical CCU, as shown in Figure 16, the two's complement multiply operation requires only three lines of microcode, as shown in Figure 19, and is executed in 17 microcycles.

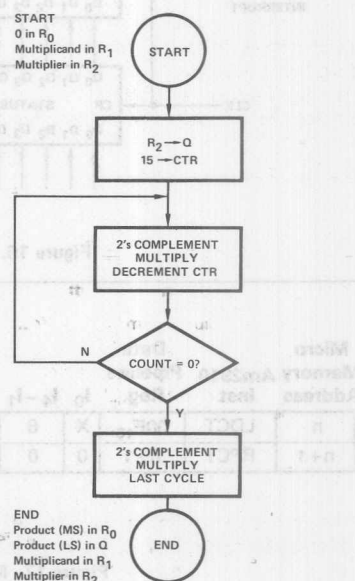
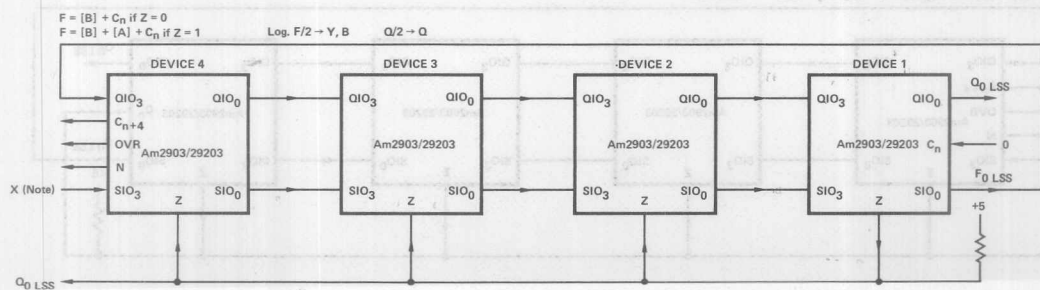


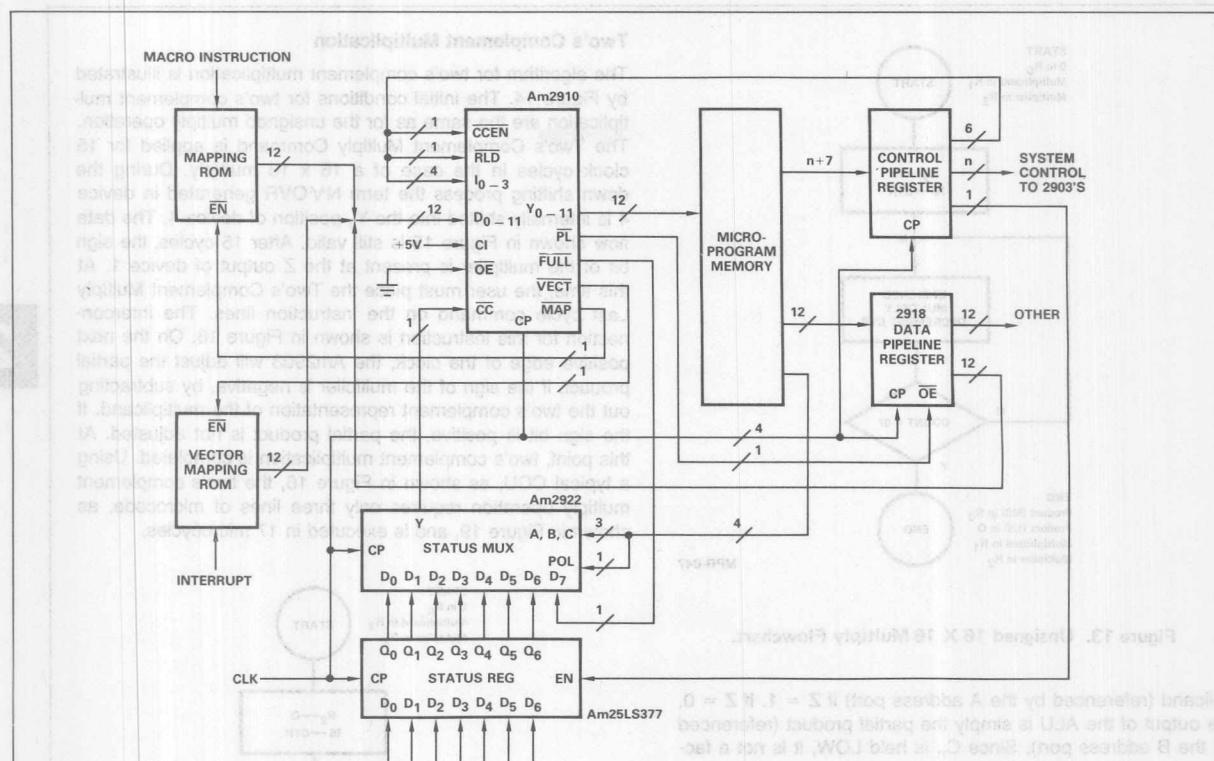
Figure 14. 2's Complement 16 X 16 Multiply.



Note: For unsigned multiply,  $C_{n+4}$  MSS is internally shifted into position  $Y_3$  MSS; 2's complement multiply  $N\overline{V}OVR$  is internally shifted into position  $Y_3$  MSS.

Figure 15. Multiply.

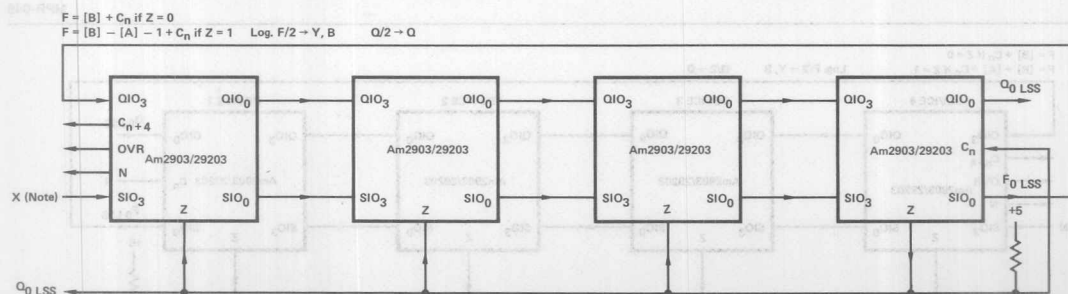
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**Figure 16. Typical Computer Control Unit (CCU).**

| Micro<br>Memory<br>Address | Data<br>Pipeline<br>Inst | Reg.              | $I_0$ | $I_4-I_1$ | $I_8-I_5$ | $\overline{OE}$ | $\overline{OEY}$ | $A_3-A_0$      | $B_3-B_0$      | $C_n$ | Comment                           |
|----------------------------|--------------------------|-------------------|-------|-----------|-----------|-----------------|------------------|----------------|----------------|-------|-----------------------------------|
|                            |                          |                   |       |           |           |                 |                  |                |                |       |                                   |
| n                          | LDCT                     | 00F <sub>16</sub> | X     | 6         | 6         | X               | X                | R <sub>2</sub> | X              | 0     | Load Counter & R <sub>2</sub> → Q |
| n+1                        | RPCT                     | n+1               | 0     | 0         | 0         | 0               | 0                | R <sub>1</sub> | R <sub>0</sub> | 0     | Unsigned Multiply                 |

**Figure 17. Micro Code for Unsigned 16 X 16 Multiply.**



Note: N  $\neq$  OVR is internally shifted into position Y<sub>3</sub> MSS.

Figure 18. 2's Complement Multiply, Last Cycle.



| Memory Address | Am2910 Inst | Data Pipeline Reg. | Data           |                                |                                |     |     |                                |                                |                |                                      |  | Comment |
|----------------|-------------|--------------------|----------------|--------------------------------|--------------------------------|-----|-----|--------------------------------|--------------------------------|----------------|--------------------------------------|--|---------|
|                |             |                    | I <sub>0</sub> | I <sub>4</sub> -I <sub>1</sub> | I <sub>8</sub> -I <sub>5</sub> | OEB | OEV | A <sub>3</sub> -A <sub>0</sub> | B <sub>3</sub> -B <sub>0</sub> | C <sub>n</sub> |                                      |  |         |
| n              | LDCT        | 00E <sub>16</sub>  | X              | 6                              | 6                              | X   | X   | R <sub>2</sub>                 | X                              | 0              | Load Counter & R <sub>2</sub> → Q    |  |         |
| n+1            | RPCT        | n+1                | 0              | 0                              | 2                              | 0   | 0   | R <sub>1</sub>                 | R <sub>0</sub>                 | 0              | 2's Complement Multiply              |  |         |
| n+2            | X           | X                  | 0              | 0                              | 6                              | 0   | 0   | R <sub>1</sub>                 | R <sub>0</sub>                 | Z              | 2's Complement Multiply (Last Cycle) |  |         |

Figure 19. Microcode for 2's Complement 16 x 16 Multiply.

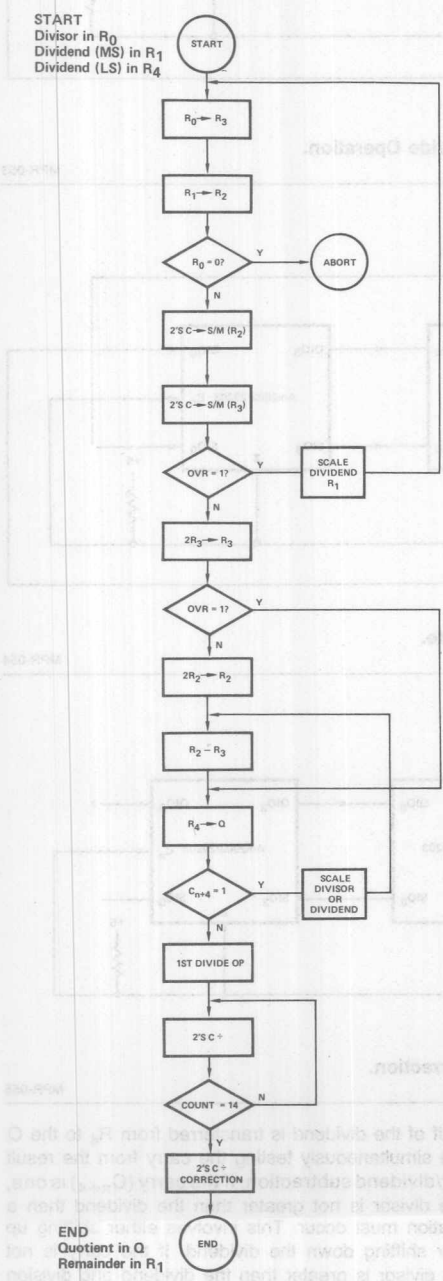


Figure 20. Division Flow Chart – Double Precision Divide.

TWO'S COMPLEMENT DIVISION

The division process is accomplished using a four quadrant non-restoring algorithm which yields an algebraically correct answer such that the divisor times the quotient plus the remainder equals the dividend. The algorithm works for both single precision and multi-precision divide operations. The only condition that needs to be met is that the absolute magnitude of the divisor be greater than the absolute magnitude of the dividend. For multi-precision divide operations the least significant bit of the dividend is truncated. This is necessary if the answer is to be algebraically correct. Bias correction is automatically provided by forcing the least significant bit of the quotient to a one, yet an algebraically correct answer is still maintained. Once the algorithm is completed, the answer may be modified to meet the user's format requirements, such as rounding off or converting the remainder so that its sign is the same as the dividend. These format modifications are accomplished using the standard Am2903 instructions.

The true value of the remainder is equal to the value stored in the working register times  $2^{n-1}$  when n is the number of quotient digits.

The following paragraphs describe a double precision divide operation. The double precision flow chart is based upon the use of the architecture detailed in Figure 16.

Referring to the flow chart outlined in Figure 20, we begin the algorithm with the assumption that the divisor is contained in R<sub>0</sub>, while the most significant and least significant halves of the dividend reside in R<sub>1</sub> and R<sub>4</sub> respectively. The first step is to duplicate the divisor by copying the contents of R<sub>0</sub> into R<sub>3</sub>. Next the most significant half of the dividend is copied by transferring the contents of R<sub>1</sub> into R<sub>2</sub> while simultaneously checking to ascertain if the divisor (R<sub>0</sub>) is zero. If the divisor is zero then division is aborted. If the divisor is not zero, the copy of the most significant half of the dividend in R<sub>2</sub> is converted from its two's complement to its sign magnitude representation. The divisor in R<sub>3</sub> is converted in like manner in the next step, while testing to see if the results of the dividend conversion yielded an indication on the overflow pin of the Am2903. If the output of the overflow pin is a 'one' then the dividend is  $-2^n$  and hence is the largest possible number, meaning that it cannot be less than the divisor. What must be done in this case is to scale the dividend by down shifting the upper and lower halves stored in R<sub>1</sub> and R<sub>4</sub> respectively. After scaling, the routine requires that the algorithm be reinitiated at the beginning.

Conversely, if the output of the overflow pin is not a one, the sign magnitude representation of the divisor (R<sub>3</sub>) is shifted up in the Am2903, removing the sign while at the same time testing the results of two's complement to sign magnitude conversion of the divisor in the Am2910. If the results of the test indicate that the divisor is  $-2^n$  i.e., overflow equals one, then the lower half of the dividend is placed in the Q register

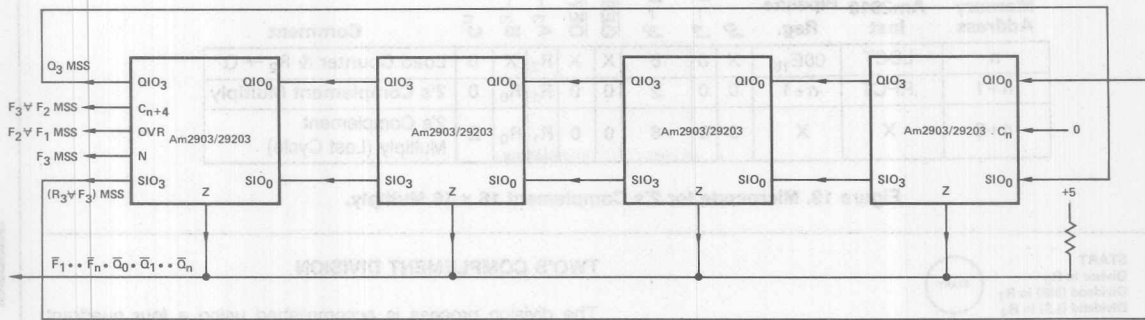


Figure 21. Double Length Normalize/First Divide Operation.

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$$F = [B] + [A] + C_n \text{ if } Z = 0$$

$$F = [B] - [A] - 1 + C_n \text{ if } Z = 1$$

$$\text{Log } 2F \rightarrow Y, B \quad 2Q \rightarrow Q$$

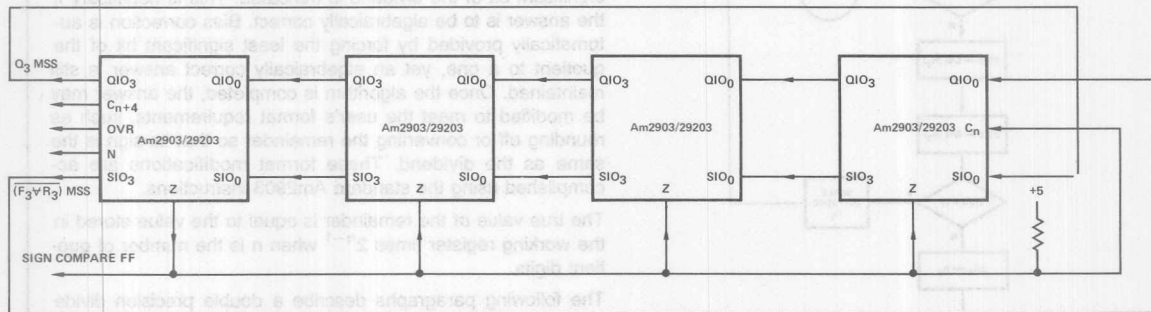


Figure 22. 2's Complement Divide.

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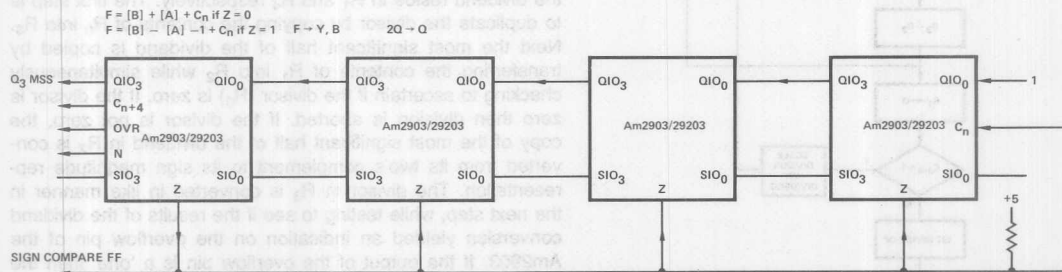


Figure 23. 2's Complement Divide Correction.

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and division may proceed. This is possible because the divisor is now guaranteed to be greater than the dividend. If overflow is not a one then we must proceed by shifting out the sign of the sign magnitude representation of the dividend stored in  $R_2$ . At this point we are able to check if the divisor is greater than the dividend by subtracting the absolute value of the divisor ( $R_3$ ) from the absolute value of the upper half of the dividend ( $R_2$ ) and storing the results in  $R_3$ . Next, the least

significant half of the dividend is transferred from  $R_4$  to the  $Q$  register while simultaneously testing the carry from the result of the divisor/dividend subtraction. If the carry ( $C_{n+4}$ ) is one, indicating the divisor is not greater than the dividend then a scaling operation must occur. This involves either shifting up the divisor or shifting down the dividend. If the carry is not one then the divisor is greater than the dividend and division may now begin.

| Micro<br>Memory<br>Address | Am2910<br>Inst. | Data<br>Pipeline<br>Reg.        | Am2903/29203   |                                |                                |                 |                                |                                |                | Am2922           |     | Comments  |
|----------------------------|-----------------|---------------------------------|----------------|--------------------------------|--------------------------------|-----------------|--------------------------------|--------------------------------|----------------|------------------|-----|---|
|                            |                 |                                 | I <sub>0</sub> | I <sub>4</sub> -I <sub>1</sub> | I <sub>8</sub> -I <sub>5</sub> | $\overline{EA}$ | A <sub>3</sub> -A <sub>0</sub> | B <sub>3</sub> -B <sub>0</sub> | C <sub>n</sub> | SEL              | POL |   |
| n                          | CONT            | X                               | 0              | 6                              | 4                              | 0               | R <sub>0</sub>                 | R <sub>3</sub>                 | 0              | X                | X   | R <sub>0</sub> → R <sub>3</sub>                               |
| n+1                        | CJP             | Abort                           | 0              | 6                              | 4                              | 0               | R <sub>1</sub>                 | R <sub>2</sub>                 | 0              | Z                | 1   | R <sub>1</sub> → R <sub>2</sub> , if R <sub>0</sub> = 0 Abort |
| n+2                        | CONT            | X                               | 0              | 0                              | 5                              | X               | X                              | R <sub>2</sub>                 | Z              | X                | X   | 2's C to S/M (R <sub>2</sub> )                                |
| n+3                        | CJP             | Scale<br>Dividend               | 0              | 0                              | 5                              | X               | X                              | R <sub>3</sub>                 | Z              | OVR              | 1   | 2's C to S/M (R <sub>3</sub> ), if<br>OVR ≥ 1, scale          |
| n+4                        | CJP             | n+7                             | 0              | 4                              | 9                              | X               | X                              | R <sub>2</sub>                 | 0              | OVR              | 1   | Shift out sign of divisor                                     |
| n+5                        | CONT            | X                               | 0              | 4                              | 9                              | X               | X                              | R <sub>3</sub>                 | 0              | X                | X   | Shift out sign of divisor                                     |
| n+6                        | CONT            | X                               | 0              | 2                              | F                              | 0               | R <sub>2</sub>                 | R <sub>3</sub>                 | 1              | X                | X   | Dividend - Divisor  |
| n+7                        | CJP             | Scale<br>Dividend<br>or Divisor | 0              | 6                              | 6                              | 0               | R <sub>4</sub>                 | X                              | 0              | C <sub>n+4</sub> | 1   | R <sub>4</sub> → Q, if<br>Carry = 1, scale                    |
| n+8                        | PUSH            | 00D <sub>16</sub>               | 0              | 0                              | A                              | 0               | R <sub>0</sub>                 | R <sub>1</sub>                 | 0              | 0                | 1   | Loop set up and<br>First Divide Operation                     |
| n+9                        | RFCT            | X                               | 0              | 0                              | C                              | 0               | R <sub>0</sub>                 | R <sub>1</sub>                 | Z              | X                | X   | Test Loop Count and<br>2's C Divide                           |
| n+A                        | CONT            | X                               | 0              | 0                              | E                              | 0               | R <sub>0</sub>                 | R <sub>1</sub>                 | Z              | X                | X   | 2's C Divide Correction                                       |

Figure 24. Microcode for Double Precision Divide.

The first divide operation is used to ascertain the sign bit of the quotient. The two's complement divide instruction is then executed repetitively, fourteen times in the case of a sixteen bit divisor and a thirty-two bit dividend. The final step is the two's complement correction command which adjusts the quotient by allowing the least significant bit of the quotient to be set to one. At the end of the division algorithm the sixteen bit quotient is found in the Q register while the remainder now replaces the most significant half of the dividend in R<sub>1</sub>. It should be noted that the remainder must be shifted down fifteen places to represent its true value. The interconnections for these instructions are shown in Figures 21, 22, 23. Using a typical CCU as shown in Figure 16, the double precision divide operation requires only eleven lines of microcode, as shown in Figure 24.

For those applications that require truncation instead of bias correction, the same algorithm as above should be implemented except one additional Two's Complement Divide instruction should be used in lieu of the Two's Complement Divide Correction and Remainder instruction. However, this technique results in an invalid remainder.

It is possible to do multiple-precision divide operations beyond the double precision divide shown above. For example, to do a triple precision divide for a 16-bit CPU, the upper two thirds of the dividend are stored in R<sub>1</sub> and Q as in the case for double precision divide. The lower third of the dividend is stored in a scratch register, R<sub>5</sub>. After checking that the magnitude of the divisor is greater than the magnitude of the dividend, using the same tests as defined in Figure 20, the procedure is as follows:

1. Execute a Double Length Normalize/First Divide Operation instruction.
2. Execute the Two's Complement Divide instruction fifteen times.
3. Transfer the contents of Q, the most significant half of the quotient, to R<sub>2</sub>.
4. Transfer R<sub>5</sub> to Q.
5. Execute the Two's Complement Divide instruction fifteen times.
6. Execute the Two's Complement Divide Correction and Remainder instruction.

The upper half of the quotient is then in R<sub>2</sub>, the lower half of the quotient is in Q and the remainder is in R<sub>1</sub>. The flow chart for this is shown in Figure 25. This technique can be expanded for any precision which is required.

#### BYTE SWAP

The multi-port architecture of the Am2903 allows for easy implementation of high- and low-order byte swapping. Figure 26 outlines a byte swap implementation utilizing two data ports. Initially, the lower order 8-bit byte is stored in devices 1 and 2, while the high-order byte is in devices 3 and 4. When the user wishes to exchange the two bytes, the register location of the desired word is placed on the B address port. When the byte swap line is brought LOW, the bytes to be swapped will be flowing from the DB ports of the Am2903 through the Am2958/2959 Three-state Buffers. The outputs of the three-

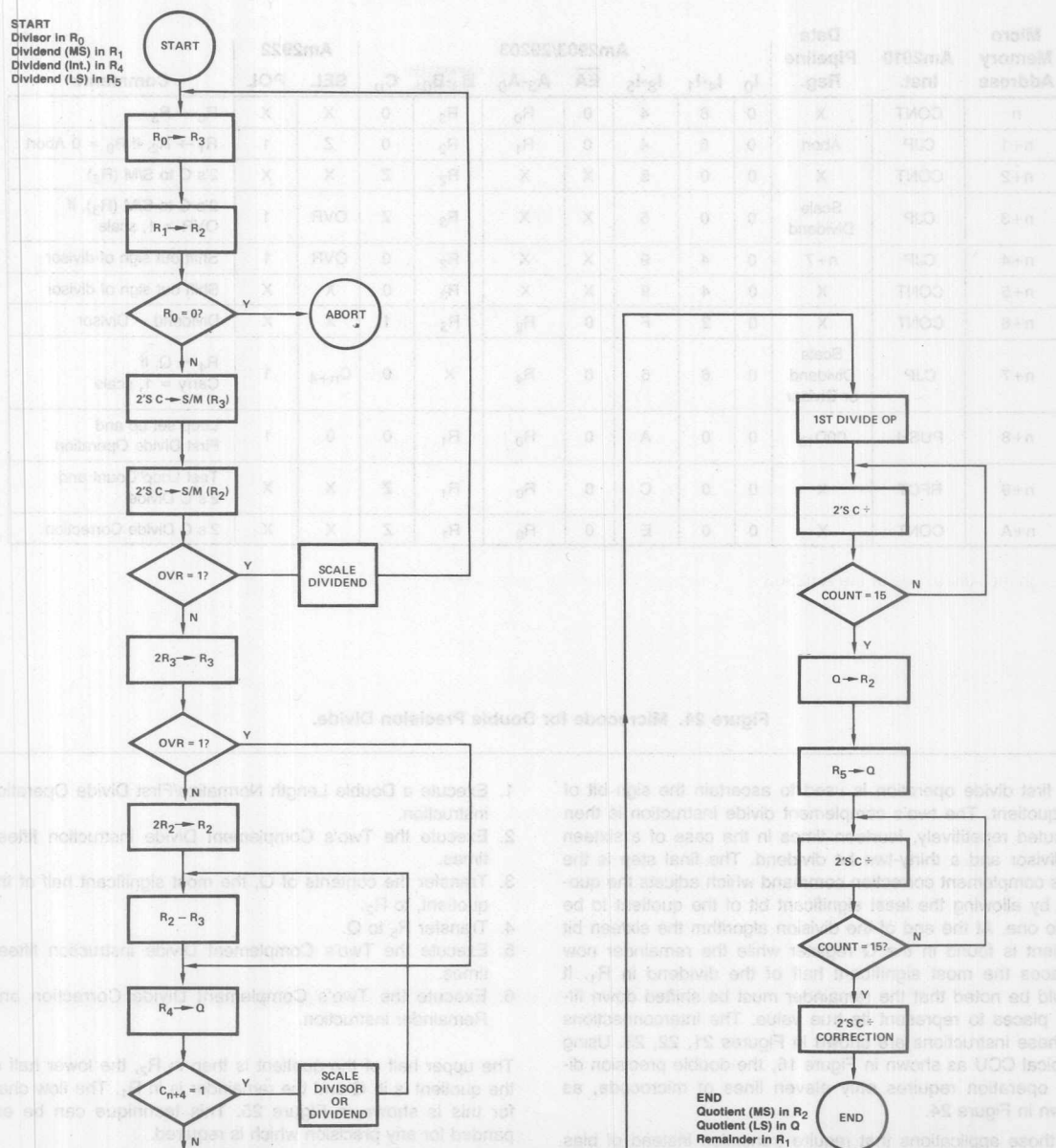


Figure 25. Division Flow Chart — Triple Precision Divide.

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state buffers are permuted such that the byte swap is achieved. The resultant permuted data is presented to the DA ports of the Am2903 where it is re-loaded into the memories of the Am2903 on the next positive edge of CP using the source and function commands of  $F = A$  plus  $C_n$  ( $C_n = 0$ ) for the Am2958 or  $F = A$  plus  $C_n$  ( $C_n = 0$ ) for the Am2959 and the destination command  $F \rightarrow Y, B$ .

A higher speed technique for achieving the byte swap operation is illustrated in Figure 27. Instead of inputting the permuted data via the DA ports, the permuted data is entered via the Y input/output ports with  $\overline{OE}_Y$  held HIGH. This technique bypasses the ALU, thus allowing faster operation. The Am2903 destination command  $F \rightarrow Y, B$  should be used.



## WORD/BYTE OPERATIONS

The Am29203 allows for Word/Byte Operations. Figure 28 pictures a 16-bit system which is capable of doing word or byte (lower half of word) operations.

In the Byte mode the  $\overline{\text{BYTE/WORD}}$  line is HIGH which in turn asserts a LOW on the  $\overline{\text{W/MSS}}$  input of Device 2 making it the MSS device. At the same time the multiplexer selects the status flags of Device 2. The  $\overline{\text{IEN}}$  and  $\overline{\text{OE}_Y}$  of Devices 4 and 3 are forced HIGH which disables them from writing into RAM or onto the Y bus.

In the word mode Device 4 is the MSS device and the multiplexer selects its status flags. The  $\overline{\text{IEN}}$  inputs are brought low which enables writing in to RAM. The  $\overline{\text{OE}_Y}$  is also allowed to go low.

## MEMORY EXPANSION

Both the Am2903 and Am29203 allow for a theoretically infinite memory expansion, but the technique is slightly different. (The Am29203 allows writing less than a full word, e.g., a byte.) Figure 29, *Am2903 and Am29705*, pictures a 4-bit slice of a system which has 48 words of RAM and 16 words of ROM. RAM storage is provided by the Am2903 and the Am29705s. The Am29705 RAM is functionally identical to the Am2903 RAM. The Am27S19 is used to store constants and masks and is addressable from address port A only. The system is organized around five data buses. Inter-bus communication may be done through the Am29705s or the Am2903. The memory addressing

scheme specifies the data source for the R input of the ALU emanating from the register locations specified by address field A.  $A_0-3$  addresses 16 memory locations in each chip while address bits  $A_4-6$  are decoded and used for the output enable for the desired chip. The B address field is used to select the S input of the ALU and the C field is used to specify the register location where the result of the ALU operation is to be stored.

Bits  $B_0-3$  are for source register addressing in each chip. Bits  $B_4$  and  $B_5$  are used for chip output enable selection.  $C_0-3$  access the 16 destination addresses on each chip while bits  $C_4$  and  $C_5$  control the Write Enable of the desired chip. The source and destination register address are multiplexed such that when the clock is HIGH, the source register address is presented to the B address ports of the RAM's. The Instruction Enable ( $\overline{\text{IEN}}$ ) is HIGH at this time. The data flows from the Y port or the internal B port as selected by the decoder whose inputs are  $B_4$  and  $B_5$ . When the clock goes LOW, the data emanating from the selected Y outputs of the Am29705's and the RAM outputs of the Am2903 are latched and the destination address is now selected for use by the RAM address lines. When the destination address stabilizes on the address lines, the  $\overline{\text{IEN}}$  pin is brought LOW. The  $\overline{\text{WRITE}}$  output of the Am2903 will now go LOW, enabling the decoder sourced by address bits  $C_4$  and  $C_5$ . The selected decoder line will go LOW, allowing the desired memory location to be written into. To switch between two- and three-address architecture, the user simply makes the source and destination addresses the same; i.e.,  $B_0-3 = C_0-3$  and  $B_4-5 = C_4-5$ . For two-address architecture, the MUX is removed from the circuit.

2

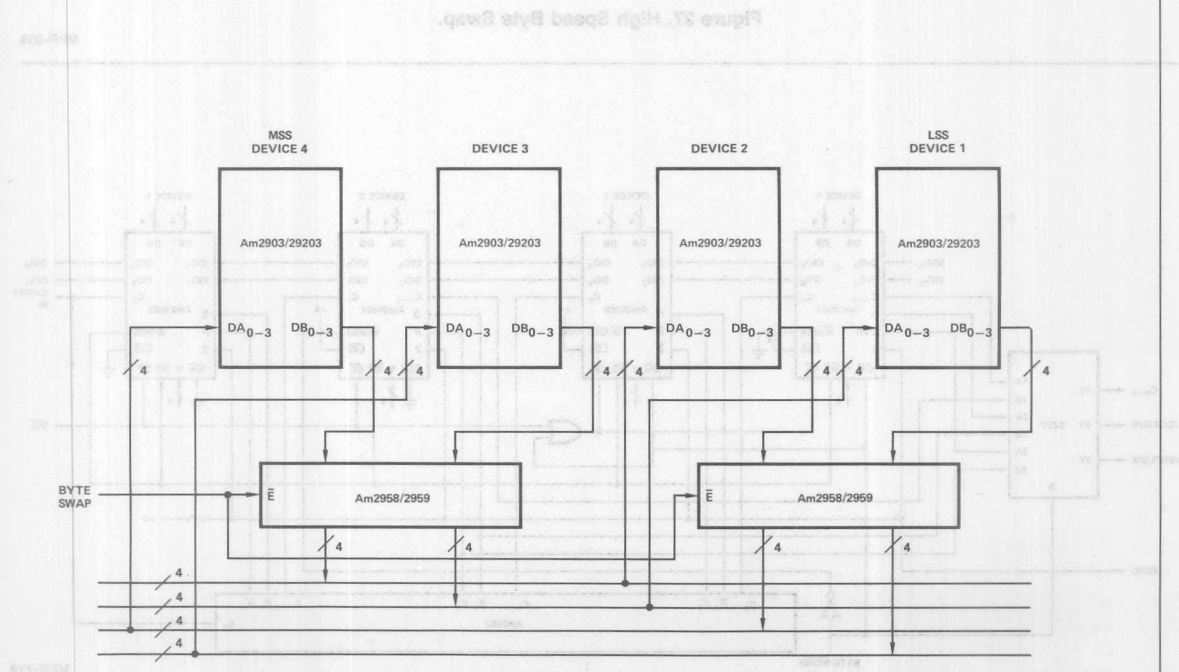


Figure 26. Byte Swap.

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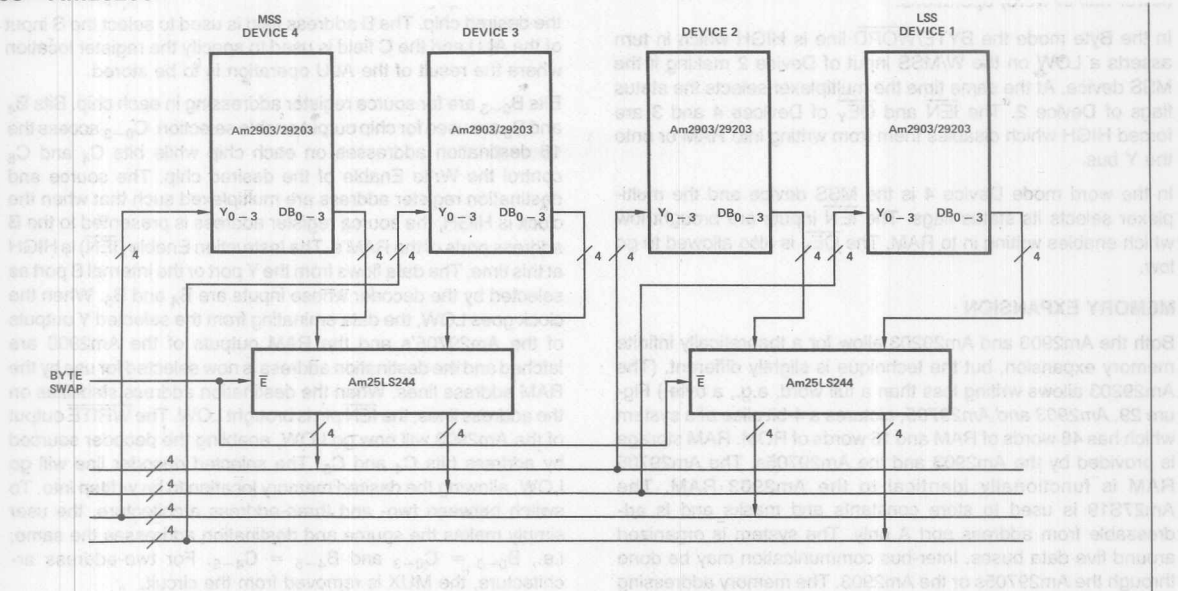
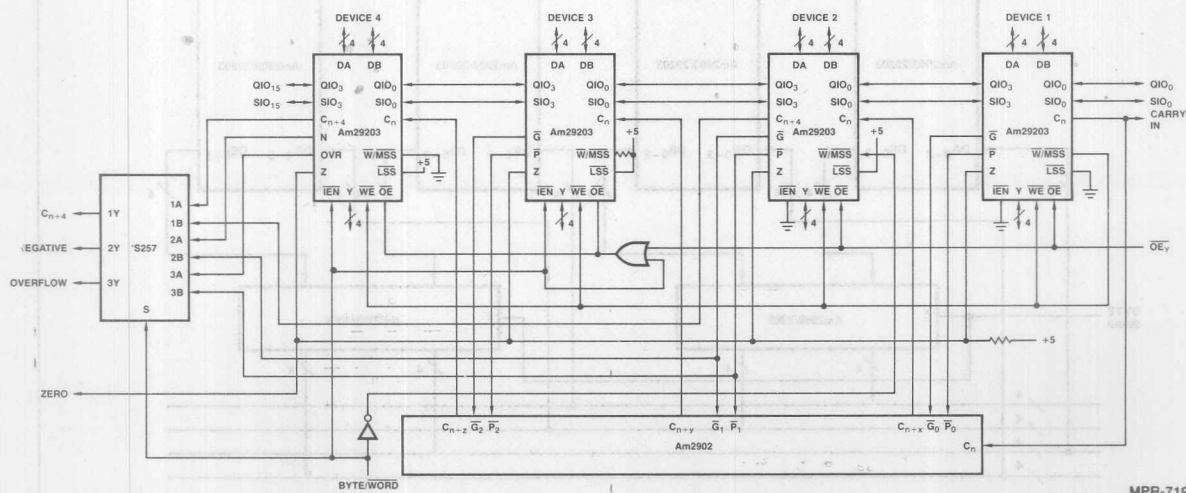


Figure 27. High Speed Byte Swap.

MPR-058



MPR-719

Figure 28. Connections for Word/Byte Operations (Am29203 Only).

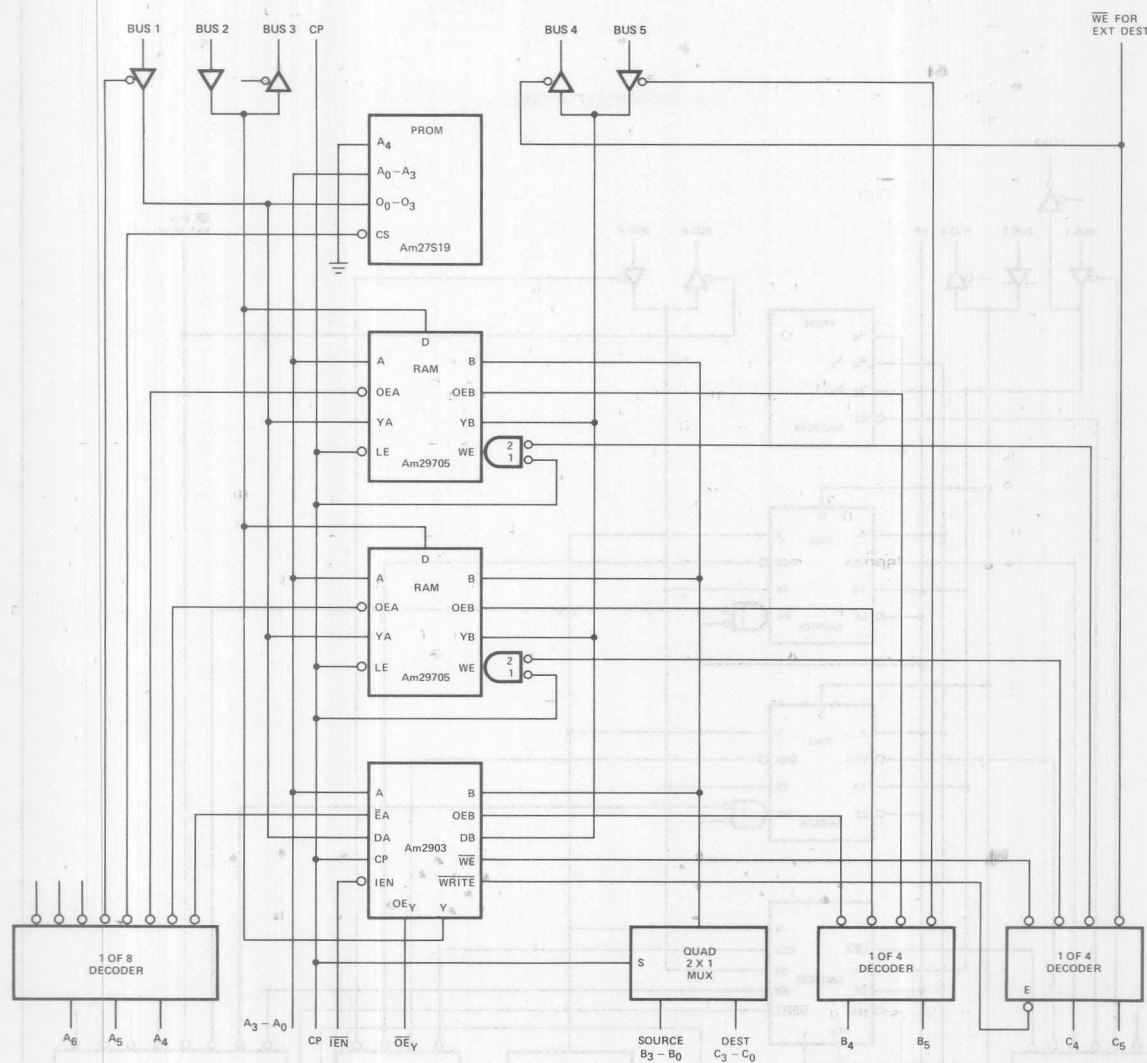


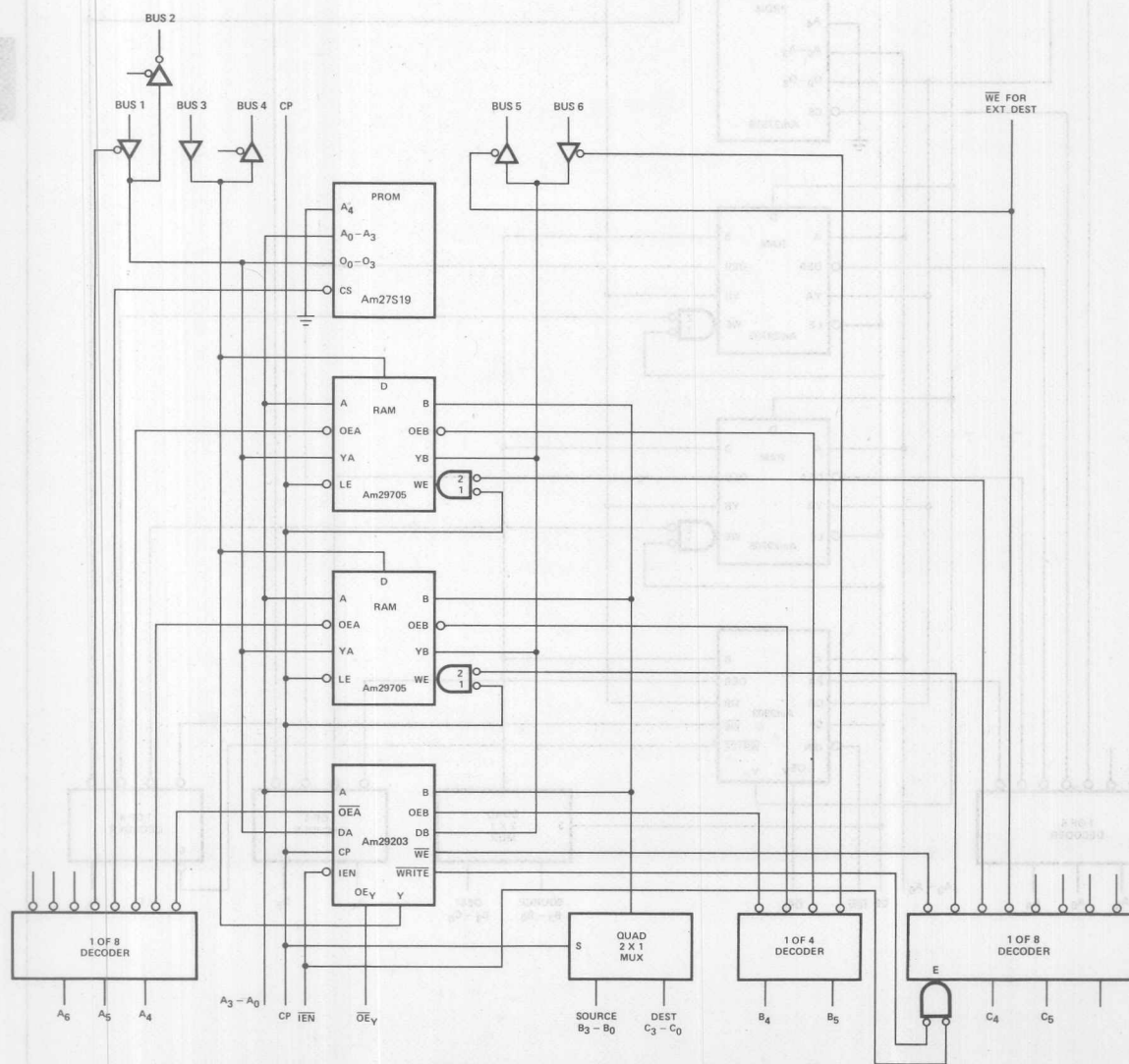
Figure 29. Expanded Memory on Am2903.

MPR-059

### Memory Expansion with the Am29203

The expansion scheme using the Am29203 and Am29705 is only slightly different from that for the Am2903, and is illustrated in Figure 30. The difference is due to the fact that the WRITE signal from the Am29203 is not internally gated by IEN. This gating is performed external to the Am29203, either in a gate or, as shown in Figure 30, by using the enable on the chip select

decoder. The advantage of separating the write signal from the IEN signal is that writing can be controlled over less than the full word length. For example, in a 16-bit system, the lower two devices can have one IEN signal and the upper two devices a second IEN signal. Controlling these two signals separately allows data to be written in either byte without disturbing the other byte. The 2- and 3-address architecture is handled in the same way as with the Am2903.



**Figure 30. Expanded Memory for Am29203.**



## APPENDIX A

### Am2903 SWITCHING CHARACTERISTICS

The switching characteristics of the Am2903 are a function of the power supply voltage, the temperature, and the operating mode of the device. The data has been condensed onto the tables on the following 24 pages. The first sets of tables define the speeds of the device for all operations except the special functions (where  $I_{43210} = 00000$ ). The remaining tables define the speeds of the combinational paths for each of the special functions. Set-up and hold times do not change for the special functions. An index to the AC tables is shown below. The roman numeral identifies the conditions:

- I = room temperature typical
- II = room temperature guaranteed
- III = guaranteed commercial operating range
- IV = guaranteed military operating range

The letter designates the type of data:

- A = standard function combinational delays
- B = set-up and hold times
- C = Enable/Disable times
- D = clock and write pulses
- E = special function combinational delays

Data is shown in Tables E in bold face where different from the data given in Tables A. Except where otherwise noted, data is taken with inputs switching between 0V and 3.0V at 1V/ns, with the measurement point at 1.5V. Outputs are measured at 1.5V and are loaded with  $C_L = 50\text{pF}$  and maximum DC load.

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#### INDEX TO SWITCHING TABLES

| Table   | Data Type             | Typical/<br>Guaranteed | Conditions                   | Applicable to                              |
|---------|-----------------------|------------------------|------------------------------|--|
| I A     | Combinational Delays  | Typical                | 5.0V, 25°C                   | Standard functions                         |
| II A    | Combinational Delays  | Guaranteed             | 5.0V, 25°C                   | Standard functions                         |
| III A   | Combinational Delays  | Guaranteed             | 4.75 to 5.25V, 0°C to +70°C  | Standard functions                         |
| III B   | Set-up and Hold Times | Guaranteed             | 4.75 to 5.25V, 0°C to +70°C  | All functions                              |
| III C   | Enable/Disable Times  | Guaranteed             | 4.75 to 5.25V, 0°C to +70°C  | All functions                              |
| III D   | Write Pulse and Clock | Guaranteed             | 4.75 to 5.25V, 0°C to +70°C  | All functions                              |
| III E-0 | Combinational Delays  | Guaranteed             | 4.75 to 5.25V, 0°C to +70°C  | Unsigned multiply instruction              |
| III E-2 | Combinational Delays  | Guaranteed             | 4.75 to 5.25V, 0°C to +70°C  | Two's complement multiply instruction      |
| III E-4 | Combinational Delays  | Guaranteed             | 4.75 to 5.25V, 0°C to +70°C  | Increment by one or two instruction        |
| III E-5 | Combinational Delays  | Guaranteed             | 4.75 to 5.25V, 0°C to +70°C  | Sign magnitude/two's complement conversion |
| III E-6 | Combinational Delays  | Guaranteed             | 4.75 to 5.25V, 0°C to +70°C  | Two's complement multiply, last cycle      |
| III E-8 | Combinational Delays  | Guaranteed             | 4.75 to 5.25V, 0°C to +70°C  | Single-length normalize                    |
| III E-A | Combinational Delays  | Guaranteed             | 4.75 to 5.25V, 0°C to +70°C  | First divide operation (dbl. length norm.) |
| III E-C | Combinational Delays  | Guaranteed             | 4.75 to 5.25V, 0°C to +70°C  | Two's complement divide                    |
| III E-E | Combinational Delays  | Guaranteed             | 4.75 to 5.25V, 0°C to +70°C  | Two's complement divide, correction        |
| IV A    | Combinational Delays  | Guaranteed             | 4.5 to 5.5V, -55°C to +125°C | Standard functions                         |
| IV B    | Set-up and Hold Times | Guaranteed             | 4.5 to 5.5V, -55°C to +125°C | All functions                              |
| IV C    | Enable/Disable Times  | Guaranteed             | 4.5 to 5.5V, -55°C to +125°C | All functions                              |
| IV D    | Write Pulse and Clock | Guaranteed             | 4.5 to 5.5V, -55°C to +125°C | All functions                              |
| IV E-0  | Combinational Delays  | Guaranteed             | 4.5 to 5.5V, -55°C to +125°C | Unsigned multiply instruction              |
| IV E-2  | Combinational Delays  | Guaranteed             | 4.5 to 5.5V, -55°C to +125°C | Two's complement multiply instruction      |
| IV E-4  | Combinational Delays  | Guaranteed             | 4.5 to 5.5V, -55°C to +125°C | Increment by one or two instruction        |
| IV E-5  | Combinational Delays  | Guaranteed             | 4.5 to 5.5V, -55°C to +125°C | Sign magnitude/two's complement conversion |
| IV E-6  | Combinational Delays  | Guaranteed             | 4.5 to 5.5V, -55°C to +125°C | Two's complement multiply, last cycle      |
| IV E-8  | Combinational Delays  | Guaranteed             | 4.5 to 5.5V, -55°C to +125°C | Single-length normalize                    |
| IV E-A  | Combinational Delays  | Guaranteed             | 4.5 to 5.5V, -55°C to +125°C | First divide operation (dbl. length norm.) |
| IV E-C  | Combinational Delays  | Guaranteed             | 4.5 to 5.5V, -55°C to +125°C | Two's complement divide                    |
| IV E-E  | Combinational Delays  | Guaranteed             | 4.5 to 5.5V, -55°C to +125°C | Two's complement divide, correction        |

TABLE I A  
Typical Combinational Delays  
 $T_A = 25^\circ\text{C}$ ,  $V_{CC} = 5.0\text{V}$   
Standard Functions

| From Input \ To Output       | Y  | $C_{n+4}$ | $\bar{G}, \bar{P}$ | Z (s) | N  | OVR | DB | $\overline{\text{WRITE}}$ | $\text{QIO}_0$<br>$\text{QIO}_3$ | $\text{SIO}_0$ | $\text{SIO}_3$ | $\text{SIO}_0$<br>Parity |
|------------------------------|----|-----------|--------------------|-------|----|-----|----|---------------------------|----------------------------------|----------------|----------------|--------------------------|
| A Address<br>(Arith. Mode)   | 54 | 48        | 43                 | 66    | 54 | 67  | —  | —                         | —                                | 52             | 58             | 74                       |
| B Address                    | 63 | 56        | 52                 | 75    | 62 | 71  | 31 | —                         | —                                | 61             | 66             | 90                       |
| A Address<br>(Logic Mode)    | 54 | —         | 42                 | 66    | 55 | —   | —  | —                         | —                                | 49             | 59             | 74                       |
| B Address                    | 53 | —         | 45                 | 63    | 53 | —   | 31 | —                         | —                                | 53             | 56             | 76                       |
| DA Inputs<br>(Arith. Mode)   | 40 | 36        | 30                 | 52    | 40 | 55  | —  | —                         | —                                | 37             | 43             | 62                       |
| DB Inputs                    | 38 | 35        | 28                 | 50    | 38 | 52  | —  | —                         | —                                | 38             | 41             | 61                       |
| DA Inputs<br>(Logic Mode)    | 40 | —         | 29                 | 52    | 40 | —   | —  | —                         | —                                | 38             | 43             | 62                       |
| DB Inputs                    | 34 | —         | 20                 | 46    | 35 | —   | —  | —                         | —                                | 34             | 38             | 57                       |
| $\bar{E}A$                   | 39 | 32        | 26                 | 51    | 39 | 52  | —  | —                         | —                                | 36             | 42             | 61                       |
| $C_n$                        | 25 | 18        | —                  | 37    | 25 | 35  | —  | —                         | —                                | 22             | 28             | 41                       |
| $I_0$                        | 33 | 29        | 22                 | 43    | 33 | 38  | —  | 33                        | *                                | 33*            | 36*            | 59*                      |
| $I_{4321}$                   | 46 | 42        | 44                 | 57    | 44 | 52  | —  | 33                        | *                                | 42*            | 47*            | 68*                      |
| $I_{8765}$                   | 28 | —         | —                  | 40    | —  | —   | —  | 32                        | 36*                              | 27*            | 28*            | 27*                      |
| $\bar{I}EN$                  | —  | —         | —                  | —     | —  | —   | —  | 12                        | —                                | —              | —              | —                        |
| $\text{SIO}_3, \text{SIO}_0$ | 15 | —         | —                  | —     | —  | —   | —  | —                         | —                                | —              | 17             | 20                       |
| Clock                        | 55 | 53        | 44                 | 67    | 57 | 67  | 23 | —                         | 25                               | 53             | 60             | 66                       |
| Y                            | —  | —         | —                  | 12    | —  | —   | —  | —                         | —                                | —              | —              | —                        |
| $\overline{\text{MSS}}$      | 28 | —         | 28                 | 40    | 28 | 28  | —  | —                         | —                                | 28             | 30             | 28                       |

Note: A "\*" means the output is enabled or disabled by the input. See Tables C for enable and disable times. A number shown with a \* is the delay to correct data on an enabled output. A \* shown without a number means the output is disabled by the input or it is enabled but the delay to correct data is determined by something else.

**Guaranteed Combinational Delays**  
**T<sub>A</sub> = 0°C to +70°C, V<sub>CC</sub> = 4.75V to 5.25V**  
**Standard Functions**

| From Input \ To Output              |    |                  |                              |       |    |     |    |       |                                      |                  |                  |                            |
|-------------------------------------|----|------------------|------------------------------|-------|----|-----|----|-------|--------------------------------------|------------------|------------------|----------------------------|
|                                     | Y  | C <sub>n+4</sub> | $\overline{G}, \overline{P}$ | Z (s) | N  | OVR | DB | WRITE | QIO <sub>0</sub><br>QIO <sub>3</sub> | SIO <sub>0</sub> | SIO <sub>3</sub> | SIO <sub>0</sub><br>Parity |
| A Address (Arith. Mode)             | 86 | 81               | 69                           | 110   | 86 | 108 | —  | —     | —                                    | 84               | 94               | 115                        |
| B Address                           | 99 | 88               | 81                           | 123   | 99 | 112 | 49 | —     | —                                    | 94               | 104              | 140                        |
| A Address (Logic Mode)              | 87 | —                | 68                           | 111   | 89 | —   | —  | —     | —                                    | 79               | 94               | 115                        |
| B Address                           | 84 | —                | 73                           | 108   | 84 | —   | 49 | —     | —                                    | 84               | 90               | 120                        |
| DA Inputs (Arith. Mode)             | 63 | 60               | 49                           | 87    | 64 | 89  | —  | —     | —                                    | 60               | 70               | 101                        |
| DB Inputs                           | 61 | 59               | 47                           | 85    | 62 | 84  | —  | —     | —                                    | 62               | 68               | 98                         |
| DA Inputs (Logic Mode)              | 64 | —                | 48                           | 88    | 66 | —   | —  | —     | —                                    | 61               | 72               | 101                        |
| DB Inputs                           | 55 | —                | 32                           | 79    | 57 | —   | —  | —     | —                                    | 52               | 61               | 93                         |
| $\overline{EA}$                     | 59 | 53               | 42                           | 83    | 59 | 83  | —  | —     | —                                    | 57               | 64               | 98                         |
| C <sub>n</sub>                      | 40 | 30               | —                            | 64    | 40 | 58  | —  | —     | —                                    | 38               | 46               | 67                         |
| I <sub>0</sub>                      | 52 | 48               | 36                           | 76    | 52 | 63  | —  | 49    | *                                    | 50*              | 58*              | 93*                        |
| I <sub>4321</sub>                   | 71 | 65               | 72                           | 95    | 69 | 84  | —  | 49    | *                                    | 66*              | 73*              | 105*                       |
| I <sub>8765</sub>                   | 42 | —                | —                            | 66    | —  | —   | —  | 50    | 60*                                  | 42*              | 45*              | 42*                        |
| $\overline{IEN}$                    | —  | —                | —                            | —     | —  | —   | —  | 22    | —                                    | —                | —                | —                          |
| SIO <sub>3</sub> , SIO <sub>0</sub> | 26 | —                | —                            | 50    | —  | —   | —  | —     | —                                    | —                | 29               | 36                         |
| Clock                               | 87 | 87               | 71                           | 111   | 88 | 108 | 37 | —     | 40                                   | 84               | 92               | 105                        |
| Y                                   | —  | —                | —                            | 24    | —  | —   | —  | —     | —                                    | —                | —                | —                          |
| MSS                                 | 44 | —                | 44                           | 68    | 44 | 44  | —  | —     | —                                    | 44               | 46               | 44                         |

Note: A "\*" means the output is enabled or disabled by the input. See Tables C for enable and disable times. A number shown with a \* is the delay to correct data on an enabled output. A \* shown without a number means the output is disabled by the input or it is enabled but the delay to correct data is determined by something else.

**TABLE III B**  
**Guaranteed Set-up and Hold Times**  
 $T_A = 0^\circ\text{C to } +70^\circ\text{C}$ ,  $V_{CC} = 4.75\text{V to } 5.25\text{V}$   
 All Functions

CAUTION: READ NOTES TO TABLE B. NA = Not Applicable; no timing constraint.

| To Output<br>From Input             | With Respect<br>to this Signal | HIGH-to-LOW |        | LOW-to-HIGH |      | Comment                                       |
|-------------------------------------|--------------------------------|-------------|--------|-------------|------|---|
|                                     |                                | Set-up      | Hold   | Set-up      | Hold |   |
| Y                                   | Clock                          | NA          | NA     | 20          | 3    | To store Y in RAM or Q                        |
| WE HIGH                             | Clock                          | 25          | Note 2 | Note 2      | 0    | To Prevent Writing                            |
| WE LOW                              | Clock                          | NA          | NA     | 30          | 0    | To Write into RAM                             |
| A, B as Sources                     | Clock                          | 27          | 3      | NA          | NA   | See Note 3                                    |
| B as a Destination                  | Clock and WE both LOW          | 6           | Note 4 | Note 4      | 3    | To Write Data only into the Correct B Address |
| QIO <sub>0</sub> , QIO <sub>3</sub> | Clock                          | NA          | NA     | 21          | 3    | To Shift Q                                    |
| I <sub>8765</sub>                   | Clock                          | 24          | Note 5 | Note 5      | 0    |   |
| IEN HIGH                            | Clock                          | 30          | Note 2 | Note 2      | 0    | To Prevent Writing into Q                     |
| IEN LOW                             | Clock                          | NA          | NA     | 30          | 0    | To Write into Q                               |
| I <sub>43210</sub>                  | Clock                          | 24          | —      | 68          | 0    | See Note 6                                    |

Notes:

- For set-up times from all inputs not specified in Table B, the set-up time is computed by calculating the delay to stable Y outputs and then allowing the Y set-up time. Even if the RAM is not being loaded, the Y set-up time is necessary to set-up the Q register. All unspecified hold times are less than or equal to zero relative to the clock LOW-to-HIGH edge.
- WE controls writing into the RAM. IEN controls writing into Q and, indirectly, controls WE through the write output. To prevent writing, IEN and WE must be HIGH during the entire clock LOW time. They may go LOW after the clock has gone LOW to cause a write provided the WE LOW and IEN LOW set-up times are met. Having gone LOW, they should not be returned HIGH until after the clock has gone HIGH.
- A and B addresses must be set-up prior to clock LOW transition to capture data in latches at RAM output.
- Writing occurs when CP and WE are both LOW. The B address should be stable during this entire period.
- Because I<sub>8765</sub> control the writing or not writing of data into RAM and Q, they should be stable during the entire clock LOW time unless IEN is HIGH, preventing writing.
- The set-up time prior to the clock LOW-to-HIGH transition occurs in parallel with the set-up time prior to the clock HIGH-to-LOW transition and the clock LOW time. The actual set-up time requirement on I<sub>43210</sub>, relative to the clock LOW-to-HIGH transition, is the longer of (1) the set-up time prior to clock L → H, and (2) the sum of the set-up time prior to clock H → L and the clock LOW time.

**TABLE III C**  
**Guaranteed Enable/Disable Times**  
 $T_A = 0^\circ\text{C to } +70^\circ\text{C}$ ,  $V_{CC} = 4.75\text{V to } 5.25\text{V}$   
 All Functions

| From               | To                                  | Enable | Disable |    |
|--------------------|-------------------------------------|--------|---------|----|
| OEY                | Y <sub>i</sub>                      | 27     | 25      | ns |
| OEB                | DB <sub>i</sub>                     | 31     | 25      | ns |
| I <sub>8</sub>     | SIO <sub>0</sub> , SIO <sub>3</sub> |        | 25      | ns |
| I <sub>8765</sub>  | QIO <sub>0</sub> , QIO <sub>3</sub> |        | 60      | ns |
| I <sub>43210</sub> | QIO <sub>0</sub> , QIO <sub>3</sub> | 65     | 60      | ns |
| LSS                | WRITE                               | 31     | 25      | ns |

Note:

- $C_L = 5.0\text{pF}$  for output disable tests. Measurement is made to a 0.5V change on the output.

**TABLE III D**  
**Guaranteed Clock and Write Pulse Characteristics**  
 $T_A = 0^\circ\text{C to } +70^\circ\text{C}$ ,  $V_{CC} = 4.75\text{V to } 5.25\text{V}$   
 All Functions

|  |    |    |
|--|----|----|
| Minimum Clock LOW Time                   | 30 | ns |
| Minimum Clock HIGH Time                  | 30 | ns |
| Minimum Time CP and WE both LOW to Write | 30 | ns |



TABLE III E-0  
Guaranteed Combinational Delays  
 $T_A = 0^\circ\text{C to } +70^\circ\text{C}$ ,  $V_{CC} = 4.75\text{V to } 5.25\text{V}$   
Unsigned Multiply Instruction  
( $I_{8765} = 0_H$ ,  $I_{4321} = 0_H$ ,  $I_0 = 0$ )

| To Output<br>From Input       | Slice<br>Position | Y          | $C_{n+4}$ | $\overline{G}, \overline{P}$ | Z (s) | N         | OVR        | DB | WRITE | $QIO_0$<br>$QIO_3$ | $SIO_0$    | $SIO_3$ | $SIO_0$<br>Parity |
|-------------------------------|-------------------|------------|-----------|------------------------------|-------|-----------|------------|----|-------|--------------------|------------|---------|-------------------|
| A, B Address<br>(Arith. Mode) | MSS               | <b>102</b> | 88        | —                            | —     | 99        | 112        | 49 | —     | —                  | 94         | —       | —                 |
|                               | IS, LSS           | 99         | 88        | 81                           | —     | —         | —          | 49 | —     | —                  | 94         | —       | —                 |
| DA, DB Inputs                 | MSS               | <b>65</b>  | 60        | —                            | —     | 64        | 89         | —  | —     | —                  | 62         | —       | —                 |
|                               | IS, LSS           | 63         | 60        | 49                           | —     | —         | —          | —  | —     | —                  | 62         | —       | —                 |
| $\overline{EA}$               | MSS               | <b>73</b>  | 53        | —                            | —     | 59        | 83         | —  | —     | —                  | 57         | —       | —                 |
|                               | IS, LSS           | 59         | 53        | 42                           | —     | —         | —          | —  | —     | —                  | 57         | —       | —                 |
| $C_n$                         | MSS               | <b>45</b>  | 30        | —                            | —     | 40        | 58         | —  | —     | —                  | 38         | —       | —                 |
|                               | IS, LSS           | 40         | 30        | —                            | —     | —         | —          | —  | —     | —                  | 38         | —       | —                 |
| $I_0$                         | MSS               | <b>94</b>  | <b>95</b> | —                            | —     | <b>87</b> | <b>102</b> | —  | —     | *                  | <b>70*</b> | *       | —                 |
|                               | IS                | <b>94</b>  | <b>95</b> | 80                           | —     | —         | —          | —  | —     | *                  | <b>70*</b> | *       | —                 |
|                               | LSS               | <b>94</b>  | <b>95</b> | 80                           | 42    | —         | —          | —  | 49    | *                  | <b>70*</b> | *       | —                 |
| $I_{4321}$                    | MSS               | <b>102</b> | <b>96</b> | —                            | —     | <b>92</b> | <b>110</b> | —  | —     | *                  | <b>72*</b> | *       | —                 |
|                               | IS                | <b>102</b> | <b>96</b> | 81                           | —     | —         | —          | —  | —     | *                  | <b>72*</b> | *       | —                 |
|                               | LSS               | <b>102</b> | <b>96</b> | 81                           | 43    | —         | —          | —  | 49    | *                  | <b>72*</b> | *       | —                 |
| $I_{8765}$                    | MSS               | <b>102</b> | <b>90</b> | —                            | —     | <b>77</b> | <b>84</b>  | —  | —     | *                  | <b>72*</b> | *       | —                 |
|                               | IS                | <b>102</b> | <b>90</b> | 84                           | —     | —         | —          | —  | —     | *                  | <b>72*</b> | *       | —                 |
|                               | LSS               | <b>102</b> | <b>90</b> | 84                           | 46    | —         | —          | —  | 50    | *                  | <b>72*</b> | *       | —                 |
| Clock                         | MSS               | <b>91</b>  | 87        | —                            | —     | 88        | 108        | 37 | —     | 40                 | 84         | —       | —                 |
|                               | IS, LSS           | 87         | 87        | 71                           | 53    | —         | —          | 37 | —     | 40                 | 84         | —       | —                 |
| Z                             | MSS               | <b>74</b>  | <b>62</b> | —                            | —     | <b>70</b> | <b>78</b>  | —  | —     | —                  | 71         | —       | —                 |
|                               | IS                | <b>74</b>  | <b>62</b> | 48                           | —     | —         | —          | —  | —     | —                  | 71         | —       | —                 |
| $\overline{IEN}$              | Any               | —          | —         | —                            | —     | —         | —          | —  | 22    | —                  | —          | —       | —                 |
| $SIO_3, SIO_0$                | Any               | 26         | —         | —                            | —     | —         | —          | —  | —     | —                  | —          | —       | —                 |

$F = S + C_n$  if  $Z = 0$

$S + R + C_n$  if  $Z = 1$

$Y_3 = C_{n+4}$  (MSS)

$Z = Q_0$  (LSS)

- Notes: 1. A "\*" means the output is enabled or disabled by the input. See Tables C for enable and disable times. A number shown with a \* is the delay to correct data on an enabled output. A \* shown without a number means the output is disabled by the input or it is enabled but the delay to correct data is determined by something else.
2. A "—" means the delay path does not exist.
3. Data in bold face is different from Table A; other data is the same.

$T_A = 0^\circ \text{ to } +70^\circ\text{C}$ ,  $V_{CC} = 4.75 \text{ to } 5.25\text{V}$   
**Two's Complement Multiply Instruction**  
 $(I_{8765} = 2_H, I_{4321} = 0_H, I_0 = 0)$

| To Output<br>From Input       | Slice<br>Position | Y          | $C_{n+4}$ | $\overline{G}, \overline{P}$ | Z (s)     | N         | OVR        | DB | $\overline{\text{WRITE}}$ | $Q_{IO_0}$<br>$Q_{IO_3}$ | $S_{IO_0}$ | $S_{IO_3}$ | $S_{IO_0}$<br>Parity |
|-------------------------------|-------------------|------------|-----------|------------------------------|-----------|-----------|------------|----|---------------------------|--------------------------|------------|------------|----------------------|
| A, B Address<br>(Arith. Mode) | MSS               | <b>106</b> | 88        | —                            | —         | 99        | 112        | 49 | —                         | —                        | 94         | —          | —                    |
|                               | IS, LSS           | 99         | 88        | 81                           | —         | —         | —          | 49 | —                         | —                        | 94         | —          | —                    |
| DA, DB Inputs                 | MSS               | <b>78</b>  | 60        | —                            | —         | 64        | 89         | —  | —                         | —                        | 62         | —          | —                    |
|                               | IS, LSS           | 63         | 60        | 49                           | —         | —         | —          | —  | —                         | —                        | 62         | —          | —                    |
| $\overline{\text{EA}}$        | MSS               | <b>85</b>  | 53        | —                            | —         | 59        | 83         | —  | —                         | —                        | 57         | —          | —                    |
|                               | IS, LSS           | 59         | 53        | 42                           | —         | —         | —          | —  | —                         | —                        | 57         | —          | —                    |
| $C_n$                         | MSS               | <b>58</b>  | 30        | —                            | —         | 40        | 58         | —  | —                         | —                        | 38         | —          | —                    |
|                               | IS, LSS           | 40         | 30        | —                            | —         | —         | —          | —  | —                         | —                        | 38         | —          | —                    |
| $I_0$                         | MSS               | <b>104</b> | <b>95</b> | —                            | —         | <b>89</b> | <b>102</b> | —  | —                         | *                        | <b>68*</b> | *          | —                    |
|                               | IS                | <b>104</b> | <b>95</b> | <b>78</b>                    | —         | —         | —          | —  | —                         | *                        | <b>68*</b> | *          | —                    |
|                               | LSS               | <b>104</b> | <b>95</b> | <b>78</b>                    | <b>42</b> | —         | —          | —  | 49                        | *                        | <b>68*</b> | *          | —                    |
| $I_{4321}$                    | MSS               | <b>112</b> | <b>95</b> | —                            | —         | <b>94</b> | <b>108</b> | —  | —                         | *                        | <b>71*</b> | *          | —                    |
|                               | IS                | <b>112</b> | <b>95</b> | <b>78</b>                    | —         | —         | —          | —  | —                         | *                        | <b>71*</b> | *          | —                    |
|                               | LSS               | <b>112</b> | <b>95</b> | <b>78</b>                    | <b>43</b> | —         | —          | —  | 49                        | *                        | <b>71*</b> | *          | —                    |
| $I_{8765}$                    | MSS               | <b>98</b>  | <b>84</b> | —                            | —         | <b>76</b> | <b>100</b> | —  | —                         | *                        | <b>71*</b> | *          | —                    |
|                               | IS                | <b>98</b>  | <b>84</b> | <b>82</b>                    | —         | —         | —          | —  | —                         | *                        | <b>71*</b> | *          | —                    |
|                               | LSS               | <b>98</b>  | <b>84</b> | <b>82</b>                    | <b>46</b> | —         | —          | —  | 50                        | *                        | <b>71*</b> | *          | —                    |
| Clock                         | MSS               | <b>100</b> | 87        | —                            | —         | 88        | 108        | 37 | —                         | 40                       | 84         | —          | —                    |
|                               | IS, LSS           | 87         | 87        | 71                           | <b>53</b> | —         | —          | 37 | —                         | 40                       | 84         | —          | —                    |
| Z                             | MSS               | <b>90</b>  | <b>62</b> | —                            | —         | <b>69</b> | <b>78</b>  | —  | —                         | —                        | <b>71</b>  | —          | —                    |
|                               | IS                | <b>90</b>  | <b>62</b> | <b>48</b>                    | —         | —         | —          | —  | —                         | —                        | <b>71</b>  | —          | —                    |
| $\overline{\text{IEN}}$       | Any               | —          | —         | —                            | —         | —         | —          | —  | 22                        | —                        | —          | —          | —                    |
| $S_{IO_3}, S_{IO_0}$          | Any               | 26         | —         | —                            | —         | —         | —          | —  | —                         | —                        | —          | —          | —                    |

$F = S + C_n$  if  $Z = 0$   
 $R + S + C_n$  if  $Z = 1$   
 $Y_3 = F_3 \oplus \text{OVR (MSS)}$   
 $Z = Q_0$  (LSS)

- Notes: 1. A "\*" means the output is enabled or disabled by the input. See Tables C for enable and disable times. A number shown with a \* is the delay to correct data on an enabled output. A \* shown without a number means the output is disabled by the input or it is enabled but the delay to correct data is determined by something else.
2. A "—" means the delay path does not exist.
3. Data in bold face is different from Table A; other data is the same.

TABLE III E-4  
Guaranteed Combinational Delays  
 $T_A = 0^\circ\text{C to } +70^\circ\text{C}$ ,  $V_{CC} = 4.75\text{V to } 5.25\text{V}$   
Increment by One or Two Instruction  
( $I_{8765} = 4_H$ ,  $I_{4321} = 0_H$ ,  $I_0 = 0$ )

| To Output<br>From Input      | Slice<br>Position | Y              | $C_{n+4}$ | $\overline{G}, \overline{P}$ | Z (s) | N  | OVR | DB | WRITE | $QIO_0$<br>$QIO_3$ | $SIO_0$ | $SIO_3$ | $SIO_0$<br>Parity |
|------------------------------|-------------------|----------------|-----------|------------------------------|-------|----|-----|----|-------|--------------------|---------|---------|-------------------|
| A, B Address<br>(Arith. Mod) | MSS               | 99             | 88        | —                            | 123   | 99 | 112 | 49 | —     | —                  | —       | —       | 140               |
|                              | IS, LSS           | 99             | 88        | 81                           | 123   | —  | —   | 49 | —     | —                  | —       | —       | 140               |
| DA, DB Inputs                | MSS               | 63             | 60        | —                            | 87    | 64 | 89  | —  | —     | —                  | —       | —       | 101               |
|                              | IS, LSS           | 63             | 60        | 49                           | 87    | —  | —   | —  | —     | —                  | —       | —       | 101               |
| $\overline{EA}$              | MSS               | —              | —         | —                            | —     | —  | —   | —  | —     | —                  | —       | —       | —                 |
|                              | IS, LSS           | —              | —         | —                            | —     | —  | —   | —  | —     | —                  | —       | —       | —                 |
| $C_n$                        | MSS               | 40             | 30        | —                            | 64    | 40 | 58  | —  | —     | —                  | —       | —       | 67                |
|                              | IS, LSS           | 40             | 30        | —                            | 64    | 40 | 58  | —  | —     | —                  | —       | —       | 67                |
| $I_0$                        | MSS               | 66             | 60        | —                            | 90    | 71 | 82  | —  | —     | *                  | *       | *       | 103*              |
|                              | IS                | 66             | 60        | 58                           | 90    | —  | —   | —  | —     | *                  | *       | *       | 103*              |
|                              | LSS               | 66             | 60        | 58                           | 90    | —  | —   | —  | 49    | *                  | *       | *       | 103*              |
| $I_{4321}$                   | MSS               | 71             | 60        | —                            | 95    | 72 | 80  | —  | —     | *                  | *       | *       | 102*              |
|                              | IS                | 71             | 60        | 58                           | 95    | —  | —   | —  | —     | *                  | *       | *       | 102*              |
|                              | LSS               | 71             | 60        | 58                           | 95    | —  | —   | —  | 49    | *                  | *       | *       | 102*              |
| $I_{8765}$                   | MSS               | 71             | 60        | —                            | 95    | 72 | 82  | —  | —     | *                  | *       | *       | 102*              |
|                              | IS                | 71             | 60        | 58                           | 95    | —  | —   | —  | —     | *                  | *       | *       | 102*              |
|                              | LSS               | 71             | 60        | 58                           | 95    | —  | —   | —  | 50    | *                  | *       | *       | 102*              |
| Clock                        | MSS               | 87             | 87        | 71                           | 111   | 88 | 108 | 37 | —     | 40                 | —       | —       | 105               |
|                              | IS, LSS           | 87             | 87        | 71                           | 111   | 88 | 108 | 37 | —     | 40                 | —       | —       | 105               |
| Z                            | MSS               | Z is an output |           |                              |       |    |     |    |       |                    |         |         |                   |
|                              | IS, LSS           | Z is an output |           |                              |       |    |     |    |       |                    |         |         |                   |
| Y                            | Any               | —              | —         | —                            | 24    | —  | —   | —  | —     | —                  | —       | —       | —                 |
| $\overline{IEN}$             | Any               | —              | —         | —                            | —     | —  | —   | —  | 22    | —                  | —       | —       | —                 |
| $SIO_3, SIO_0$               | Any               | 26             | —         | —                            | —     | —  | —   | —  | —     | —                  | —       | —       | —                 |

$$F = S + 1 + C_n$$

- Notes: 1. A "\*" means the output is enabled or disabled by the input. See Tables C for enable and disable times. A number shown with a \* is the delay to correct data on an enabled output. A \* shown without a number means the output is disabled by the input or it is enabled but the delay to correct data is determined by something else.
2. A "—" means the delay path does not exist.
3. Data in bold face is different from Table A; other data is the same.

TABLE III E-5  
 Guaranteed Combinational Delays  
 $T_A = 0^\circ\text{C to } +70^\circ\text{C}$ ,  $V_{CC} = 4.75\text{V to } 5.25\text{V}$   
 Sign Magnitude/Two's Complement Conversion  
 ( $I_{8765} = 5H$ ,  $I_{4321} = 0H$ ,  $I_0 = 0$ )

| To Output<br>From Input             | Slice<br>Position | Y              | $C_{n+4}$ | $\overline{G}, \overline{P}$ | Z (s) | N   | OVR | DB | WRITE | QIO <sub>0</sub><br>QIO <sub>3</sub> | SIO <sub>0</sub> | SIO <sub>3</sub> | SIO <sub>0</sub><br>Parity |
|-------------------------------------|-------------------|----------------|-----------|------------------------------|-------|-----|-----|----|-------|--------------------------------------|------------------|------------------|----------------------------|
| A, B Address<br>(Arith. Mode)       | MSS               | 138            | 88        | —                            | 70    | 138 | 112 | 49 | —     | —                                    | —                | —                | 140                        |
|                                     | IS, LSS           | 99             | 88        | 81                           | —     | —   | —   | 49 | —     | —                                    | —                | —                | 140                        |
| DA, DB Inputs                       | MSS               | 98             | 60        | —                            | 40    | 98  | 89  | —  | —     | —                                    | —                | —                | 101                        |
|                                     | IS, LSS           | 63             | 60        | 49                           | —     | —   | —   | —  | —     | —                                    | —                | —                | 101                        |
| $\overline{EA}$                     | MSS               | —              | —         | —                            | —     | —   | —   | —  | —     | —                                    | —                | —                | —                          |
|                                     | IS, LSS           | —              | —         | —                            | —     | —   | —   | —  | —     | —                                    | —                | —                | —                          |
| $C_n$                               | MSS               | 79             | 30        | —                            | —     | 79  | 58  | —  | —     | —                                    | —                | —                | 67                         |
|                                     | IS, LSS           | 40             | 30        | —                            | —     | —   | —   | —  | —     | —                                    | —                | —                | 67                         |
| $I_0$                               | MSS               | 102            | 78        | —                            | 46    | 100 | 112 | —  | —     | *                                    | *                | *                | 131*                       |
|                                     | IS                | 102            | 78        | 70                           | —     | —   | —   | —  | —     | *                                    | *                | *                | 131*                       |
|                                     | LSS               | 102            | 78        | 70                           | —     | —   | —   | 49 | —     | *                                    | *                | *                | 131*                       |
| $I_{4321}$                          | MSS               | 102            | 78        | —                            | 46    | 100 | 103 | —  | —     | *                                    | *                | *                | 131*                       |
|                                     | IS                | 102            | 78        | 72                           | —     | —   | —   | —  | —     | *                                    | *                | *                | 131*                       |
|                                     | LSS               | 102            | 78        | 72                           | —     | —   | —   | 49 | —     | *                                    | *                | *                | 131*                       |
| $I_{8765}$                          | MSS               | 100            | 78        | —                            | 46    | 97  | 105 | —  | —     | *                                    | *                | *                | 138*                       |
|                                     | IS                | 100            | 78        | 65                           | —     | —   | —   | —  | —     | *                                    | *                | *                | 138*                       |
|                                     | LSS               | 100            | 78        | 65                           | —     | —   | —   | 50 | —     | *                                    | *                | *                | 138*                       |
| Clock                               | MSS               | 118            | 87        | 71                           | 58    | 118 | 108 | 37 | —     | —                                    | —                | —                | 105                        |
|                                     | IS, LSS           | 87             | 87        | 71                           | —     | —   | —   | 37 | —     | —                                    | —                | —                | 105                        |
| Z                                   | MSS               | Z is an output |           |                              |       |     |     |    |       |                                      |                  |                  |                            |
|                                     | IS, LSS           | 72             | 60        | 48                           | —     | —   | —   | —  | —     | —                                    | —                | —                | 114                        |
| $\overline{IEN}$                    | Any               | —              | —         | —                            | —     | —   | —   | —  | 22    | —                                    | —                | —                | —                          |
| SIO <sub>3</sub> , SIO <sub>0</sub> | Any               | 26             | —         | —                            | —     | —   | —   | —  | —     | —                                    | —                | —                | —                          |

$$F = S + C_n \text{ if } Z = 0$$

$$\overline{S} + C_n \text{ if } Z = 1$$

$$Y_3 = S_3 \oplus F_3 \text{ (MSS)}$$

$$Z = S_3 \text{ (MSS)}$$

Notes: 1. A "\*" means the output is enabled or disabled by the input. See Tables C for enable and disable times. A number shown with a \* is the delay to correct data on an enabled output. A \* shown without a number means the output is disabled by the input or it is enabled but the delay to correct data is determined by something else.

2. A "—" means the delay path does not exist.

3. Data in bold face is different from Table A; other data is the same.



TABLE III E-6  
Guaranteed Combinational Delays  
 $T_A = 0^\circ\text{C to } +70^\circ\text{C}$ ,  $V_{CC} = 4.75\text{V to } 5.25\text{V}$   
Two's Complement Multiply, Last Cycle  
( $I_{8765} = 6_H$ ,  $I_{4321} = 0_H$ ,  $I_0 = 0$ )

| To Output<br>From Input       | Slice<br>Position | Y   | $C_{n+4}$ | $\bar{G}, \bar{P}$ | Z (s) | N  | OVR | DB | WRITE | $QIO_0$<br>$QIO_3$ | $SIO_0$<br>$SIO_3$ | $SIO_0$<br>Parity |
|-------------------------------|-------------------|-----|-----------|--------------------|-------|----|-----|----|-------|--------------------|--------------------|-------------------|
| A, B Address<br>(Arith. Mode) | MSS               | 120 | 88        | —                  | —     | 99 | 112 | 49 | —     | —                  | 94                 | —                 |
|                               | IS, LSS           | 99  | 88        | 81                 | —     | —  | —   | 49 | —     | —                  | 94                 | —                 |
| DA, DB Inputs                 | MSS               | 85  | 60        | —                  | —     | 64 | 89  | —  | —     | —                  | 62                 | —                 |
|                               | IS, LSS           | 63  | 60        | 49                 | —     | —  | —   | —  | —     | —                  | 62                 | —                 |
| $\bar{E}A$                    | MSS               | 93  | 53        | —                  | —     | 59 | 83  | —  | —     | —                  | 57                 | —                 |
|                               | IS, LSS           | 59  | 53        | 42                 | —     | —  | —   | —  | —     | —                  | 57                 | —                 |
| $C_n$                         | MSS               | 64  | 30        | —                  | —     | 40 | 58  | —  | —     | —                  | 38                 | —                 |
|                               | IS, LSS           | 40  | 30        | —                  | —     | —  | —   | —  | —     | —                  | 38                 | —                 |
| $I_0$                         | MSS               | 112 | 99        | —                  | —     | 91 | 120 | —  | —     | *                  | 98*                | *                 |
|                               | IS                | 112 | 99        | 86                 | —     | —  | —   | —  | —     | *                  | 98*                | *                 |
|                               | LSS               | 112 | 99        | 86                 | 42    | —  | —   | —  | 49    | *                  | 98*                | *                 |
| $I_{4321}$                    | MSS               | 115 | 93        | —                  | —     | 94 | 124 | —  | —     | *                  | 97*                | *                 |
|                               | IS                | 115 | 93        | 85                 | —     | —  | —   | —  | —     | *                  | 97*                | *                 |
|                               | LSS               | 115 | 93        | 85                 | 43    | —  | —   | —  | 49    | *                  | 97*                | *                 |
| $I_{8765}$                    | MSS               | 105 | 93        | —                  | —     | 88 | 114 | —  | —     | *                  | 96*                | *                 |
|                               | IS                | 105 | 93        | 78                 | —     | —  | —   | —  | —     | *                  | 96*                | *                 |
|                               | LSS               | 105 | 93        | 78                 | 50    | —  | —   | —  | 50    | *                  | 96*                | *                 |
| Clock                         | MSS               | 110 | 87        | —                  | —     | 88 | 108 | 37 | —     | 40                 | 84                 | —                 |
|                               | IS, LSS           | 87  | 87        | 71                 | 53    | —  | —   | 37 | —     | 40                 | 84                 | —                 |
| Z                             | MSS               | 91  | 64        | —                  | —     | 74 | 98  | —  | —     | —                  | 70                 | —                 |
|                               | IS                | 91  | 64        | 50                 | —     | —  | —   | —  | —     | —                  | 70                 | —                 |
| $\bar{I}EN$                   | Any               | —   | —         | —                  | —     | —  | —   | —  | 22    | —                  | —                  | —                 |
| $SIO_3, SIO_0$                | Any               | 26  | —         | —                  | —     | —  | —   | —  | —     | —                  | —                  | —                 |

$$F = S + C_n \text{ if } Z = 0$$

$$S = R - 1 + C_n \text{ if } Z = 1$$

$$Y_3 = OVR \oplus F_3 \text{ (MSS)}$$

$$Z = Q_0 \text{ (LSS)}$$

Notes: 1. A "\*" means the output is enabled or disabled by the input. See Tables C for enable and disable times. A number shown with a \* is the delay to correct data on an enabled output. A \* shown without a number means the output is disabled by the input or it is enabled but the delay to correct data is determined by something else.

2. A "—" means the delay path does not exist.

3. Data in bold face is different from Table A; other data is the same.

**Guaranteed Combinational Delays**  
 $T_A = 0^\circ\text{C to } +70^\circ\text{C}$ ,  $V_{CC} = 4.75\text{V to } 5.25\text{V}$   
**Single-Length Normalize Instruction**  
 $(I_{8765} = 8_H, I_{4321} = 0_H, I_0 = 0)$

| To Output<br>From Input       | Slice<br>Position | Y              | $C_{n+4}$ | $\overline{G}, \overline{P}$ | Z (s) | N  | OVR | DB | $\overline{\text{WRITE}}$ | $QIO_0$<br>$QIO_3$ | $SIO_0$ | $SIO_3$ | $SIO_0$<br>Parity |
|-------------------------------|-------------------|----------------|-----------|------------------------------|-------|----|-----|----|---------------------------|--------------------|---------|---------|-------------------|
| A, B Address<br>(Arith. Mode) | MSS               | 99             | 88        | —                            | —     | 99 | 112 | 49 | —                         | —                  | —       | —       | —                 |
|                               | IS, LSS           | 99             | 88        | 81                           | —     | —  | —   | 49 | —                         | —                  | —       | —       | —                 |
| DA, DB Inputs                 | MSS               | 63             | 60        | —                            | —     | 64 | 89  | —  | —                         | —                  | —       | —       | —                 |
|                               | IS, LSS           | 63             | 60        | 49                           | —     | —  | —   | —  | —                         | —                  | —       | —       | —                 |
| $\overline{EA}$               | MSS               | 59             | 53        | —                            | —     | 59 | 83  | —  | —                         | —                  | —       | —       | —                 |
|                               | IS, LSS           | 59             | 53        | 42                           | —     | —  | —   | —  | —                         | —                  | —       | —       | —                 |
| $C_n$                         | MSS               | 40             | 30        | —                            | —     | 40 | 58  | —  | —                         | —                  | —       | —       | —                 |
|                               | IS, LSS           | 40             | 30        | —                            | —     | —  | —   | —  | —                         | —                  | —       | —       | —                 |
| $I_0$                         | MSS               | 67             | 52        | —                            | 33    | 45 | 42  | —  | —                         | *                  | *       | 72*     | —                 |
|                               | IS                | 67             | 52        | 58                           | 33    | —  | —   | —  | —                         | *                  | *       | 72*     | —                 |
|                               | LSS               | 67             | 52        | 58                           | 33    | —  | —   | —  | 49                        | *                  | *       | 72*     | —                 |
| $I_{4321}$                    | MSS               | 68             | 58        | —                            | 34    | 45 | 47  | —  | —                         | *                  | *       | 72*     | —                 |
|                               | IS                | 68             | 58        | 58                           | 36    | —  | —   | —  | —                         | *                  | *       | 72*     | —                 |
|                               | LSS               | 68             | 58        | 58                           | 36    | —  | —   | —  | 49                        | *                  | *       | 72*     | —                 |
| $I_{8765}$                    | MSS               | 66             | 70        | —                            | 44    | 50 | 47  | —  | —                         | *                  | *       | 72*     | —                 |
|                               | IS                | 66             | 70        | 41                           | 44    | —  | —   | —  | —                         | *                  | *       | 72*     | —                 |
|                               | LSS               | 66             | 70        | 41                           | 44    | —  | —   | —  | 50                        | *                  | *       | 72*     | —                 |
| Clock                         | MSS               | 87             | 49        | —                            | 46    | 49 | 47  | 37 | —                         | 40                 | —       | 92      | —                 |
|                               | IS, LSS           | 87             | 87        | 71                           | 48    | —  | —   | 37 | —                         | 40                 | —       | 92      | —                 |
| Z                             | MSS               | Z is an output |           |                              |       |    |     |    |                           |                    |         |         |                   |
|                               | IS, LSS           | Z is an output |           |                              |       |    |     |    |                           |                    |         |         |                   |
| $\overline{IEN}$              | Any               | —              | —         | —                            | —     | —  | —   | —  | 22                        | —                  | —       | —       | —                 |
| $SIO_3, SIO_0$                | Any               | 26             | —         | —                            | —     | —  | —   | —  | —                         | —                  | —       | —       | —                 |

$$F = S + C_n$$

$$C_{n+4} = Q_3 \oplus Q_2 \text{ (MSS)}$$

$$OVR = Q_2 \oplus Q_1 \text{ (MSS)}$$

$$N = Q_3 \text{ (MSS)}$$

$$Z = \overline{Q_0} \overline{Q_1} \overline{Q_2} \overline{Q_3}$$

Notes: 1. A "\*" means the output is enabled or disabled by the input. See Tables C for enable and disable times. A number shown with a \* is the delay to correct data on an enabled output. A \* shown without a number means the output is disabled by the input or it is enabled but the delay to correct data is determined by something else.

2. A "—" means the delay path does not exist.

3. Data in bold face is different from Table A; other data is the same.

TABLE III E-A  
Guaranteed Combinational Delays  
 $T_A = 0^\circ\text{C}$  to  $+70^\circ\text{C}$ ,  $V_{CC} = 4.75\text{V}$  to  $5.25\text{V}$   
First Divide Operation (Double Length Normalize)  
( $I_{8765} = A_H$ ,  $I_{4321} = 0_H$ ,  $I_0 = 0$ )

| To Output<br>From Input       | Slice<br>Position | Y              | $C_{n+4}$ | $\bar{G}, \bar{P}$ | Z (s) | N  | OVR | DB | WRITE | $Q_{IO_0}$<br>$Q_{IO_3}$ | $SIO_0$ | $SIO_3$ | $SIO_0$<br>Parity |
|-------------------------------|-------------------|----------------|-----------|--------------------|-------|----|-----|----|-------|--------------------------|---------|---------|-------------------|
| A, B Address<br>(Arith. Mode) | MSS               | 99             | 113       | —                  | 94    | 94 | 102 | 49 | —     | —                        | —       | 120     | —                 |
|                               | IS, LSS           | 99             | 88        | 81                 | —     | —  | —   | 49 | —     | —                        | —       | 104     | —                 |
| DA, DB Inputs                 | MSS               | 63             | 75        | —                  | 54    | 54 | 62  | —  | —     | —                        | —       | 80      | —                 |
|                               | IS, LSS           | 63             | 60        | 49                 | —     | —  | —   | —  | —     | —                        | —       | 70      | —                 |
| $\bar{E}A$                    | MSS               | —              | —         | —                  | —     | —  | —   | —  | —     | —                        | —       | 76      | —                 |
|                               | IS, LSS           | —              | —         | —                  | —     | —  | —   | —  | —     | —                        | —       | 64      | —                 |
| $C_n$                         | MSS               | 40             | 54        | —                  | 45    | 45 | 50  | —  | —     | —                        | —       | 68      | —                 |
|                               | IS, LSS           | 40             | 30        | —                  | —     | —  | —   | —  | —     | —                        | —       | 46      | —                 |
| $I_0$                         | MSS               | 69             | 95        | —                  | 68    | 72 | 86  | —  | —     | *                        | *       | 96 *    | —                 |
|                               | IS                | 69             | 95        | 56                 | 68    | —  | —   | —  | —     | *                        | *       | 96 *    | —                 |
|                               | LSS               | 69             | 95        | 56                 | 68    | —  | —   | —  | 49    | *                        | *       | 96 *    | —                 |
| $I_{4321}$                    | MSS               | 69             | 94        | —                  | 68    | 72 | 86  | —  | —     | *                        | *       | 96 *    | —                 |
|                               | IS                | 69             | 94        | 57                 | 68    | —  | —   | —  | —     | *                        | *       | 96 *    | —                 |
|                               | LSS               | 69             | 94        | 57                 | 68    | —  | —   | —  | 49    | *                        | *       | 96 *    | —                 |
| $I_{8765}$                    | MSS               | 69             | 95        | —                  | 68    | 72 | 86  | —  | —     | *                        | *       | 96 *    | —                 |
|                               | IS                | 69             | 95        | 57                 | 68    | —  | —   | —  | —     | *                        | *       | 96 *    | —                 |
|                               | LSS               | 69             | 95        | 57                 | 68    | —  | —   | —  | 50    | *                        | *       | 96 *    | —                 |
| Clock                         | MSS               | 87             | 101       | —                  | 80    | 84 | 89  | 37 | —     | 40                       | —       | 106     | —                 |
|                               | IS, LSS           | 87             | 87        | 71                 | 80    | —  | —   | 37 | —     | 40                       | —       | 92      | —                 |
| Z                             | MSS               | Z is an output |           |                    |       |    |     |    |       |                          |         |         |                   |
|                               | IS                | Z is an output |           |                    |       |    |     |    |       |                          |         |         |                   |
| $\bar{T}EN$                   | Any               | —              | —         | —                  | —     | —  | —   | —  | 22    | —                        | —       | —       | —                 |
| $SIO_3, SIO_0$                | Any               | 26             | —         | —                  | —     | —  | —   | —  | —     | —                        | —       | —       | —                 |

$$\begin{aligned}
 F &= S + C_n \\
 N &= F_3 \text{ (MSS)} \\
 SIO_3 &= F_3 \oplus R_3 \text{ (MSS)} \\
 C_{n+4} &= F_3 \oplus F_2 \text{ (MSS)} \\
 OVR &= F_2 \oplus F_1 \text{ (MSS)} \\
 Z &= \bar{Q}_0 \bar{Q}_1 \bar{Q}_2 \bar{Q}_3 F_0 F_1 F_2 F_3
 \end{aligned}$$

- Notes: 1. A "\*" means the output is enabled or disabled by the input. See Tables C for enable and disable times. A number shown with a \* is the delay to correct data on an enabled output. A \* shown without a number means the output is disabled by the input or it is enabled but the delay to correct data is determined by something else.
2. A "—" means the delay path does not exist.
3. Data in bold face is different from Table A, other data is the same.

TABLE III E-C  
Guaranteed Combinational Delays  
 $T_A = 0^\circ\text{C}$  to  $+70^\circ\text{C}$ ,  $V_{CC} = 4.75\text{V}$  to  $5.25\text{V}$   
Two's Complement Divide Operation  
( $I_{8765} = C_H$ ,  $I_{4321} = 0_H$ ,  $I_0 = 0$ )

| To Output<br>From Input       | Slice<br>Position | Y              | $C_{n+4}$ | $\bar{G}, \bar{P}$ | Z (s) | N  | OVR | DB | WRITE | $QIO_0$<br>$QIO_3$ | $SIO_0$ | $SIO_3$ | $SIO_0$<br>Parity |
|-------------------------------|-------------------|----------------|-----------|--------------------|-------|----|-----|----|-------|--------------------|---------|---------|-------------------|
| A, B Address<br>(Arith. Mode) | MSS               | 99             | 88        | —                  | —     | 99 | 112 | 49 | —     | —                  | —       | 107     | —                 |
|                               | IS, LSS           | 99             | 88        | 81                 | —     | —  | —   | 49 | —     | —                  | —       | 104     | —                 |
| DA, DB Inputs                 | MSS               | 63             | 60        | —                  | —     | 64 | 89  | —  | —     | —                  | —       | 84      | —                 |
|                               | IS, LSS           | 63             | 60        | 49                 | —     | —  | —   | —  | —     | —                  | —       | 70      | —                 |
| $\bar{E}A$                    | MSS               | 59             | 53        | —                  | —     | 59 | 83  | —  | —     | —                  | —       | 91      | —                 |
|                               | IS, LSS           | 59             | 53        | 42                 | —     | —  | —   | —  | —     | —                  | —       | 64      | —                 |
| $C_n$                         | MSS               | 40             | 30        | —                  | —     | 40 | 58  | —  | —     | —                  | —       | 64      | —                 |
|                               | IS, LSS           | 40             | 30        | —                  | —     | —  | —   | —  | —     | —                  | —       | 46      | —                 |
| $I_0$                         | MSS               | 94             | 93        | —                  | 39    | 94 | 120 | —  | —     | *                  | *       | 108*    | —                 |
|                               | IS                | 94             | 93        | 74                 | —     | —  | —   | —  | —     | *                  | *       | 108*    | —                 |
|                               | LSS               | 94             | 93        | 74                 | —     | —  | —   | —  | 49    | *                  | *       | 108*    | —                 |
| $I_{4321}$                    | MSS               | 94             | 84        | —                  | 42    | 93 | 120 | —  | —     | *                  | *       | 108*    | —                 |
|                               | IS                | 94             | 84        | 74                 | —     | —  | —   | —  | —     | *                  | *       | 108*    | —                 |
|                               | LSS               | 94             | 84        | 74                 | —     | —  | —   | —  | 49    | *                  | *       | 108*    | —                 |
| $I_{8765}$                    | MSS               | 93             | 89        | —                  | 43    | 93 | 120 | —  | —     | *                  | *       | 108*    | —                 |
|                               | IS                | 93             | 89        | 64                 | —     | —  | —   | —  | —     | *                  | *       | 108*    | —                 |
|                               | LSS               | 93             | 89        | 64                 | —     | —  | —   | —  | 50    | *                  | *       | 108*    | —                 |
| Clock                         | MSS               | 87             | 87        | —                  | 53    | 88 | 108 | 37 | —     | 40                 | —       | 130     | —                 |
|                               | IS, LSS           | 87             | 87        | 71                 | —     | —  | —   | 37 | —     | 40                 | —       | 92      | —                 |
| Z                             | MSS               | Z is an output |           |                    |       |    |     |    |       |                    |         |         |                   |
|                               | IS, LSS           | 68             | 65        | 52                 | —     | —  | —   | —  | —     | —                  | —       | 77      | —                 |
| $\bar{I}EN$                   | Any               | —              | —         | —                  | —     | —  | —   | —  | 22    | —                  | —       | —       | —                 |
| $SIO_3, SIO_0$                | Any               | 26             | —         | —                  | —     | —  | —   | —  | —     | —                  | —       | —       | —                 |

$$F = R + S + C_n \text{ if } Z = 0$$

$$S = R - 1 + C_n \text{ if } Z = 1$$

$$SIO_3 = F_3 \oplus R_3 \text{ (MSS)}$$

$$Z = F_3 \oplus R_3 \text{ (MSS) from previous cycle}$$

Notes: 1. A "\*" means the output is enabled or disabled by the input. See Tables C for enable and disable times. A number shown with a \* is the delay to correct data on an enabled output. A \* shown without a number means the output is disabled by the input or it is enabled but the delay to correct data is determined by something else.

2. A "—" means the delay path does not exist.

3. Data in bold face is different from Table A; other data is the same.



TABLE III E-E  
Guaranteed Combinational Delays  
 $T_A = 0^\circ\text{C}$  to  $+70^\circ\text{C}$ ,  $V_{CC} = 4.75\text{V}$  to  $5.25\text{V}$   
Two's Complement Divide, Correction  
( $I_{8765} = E_H$ ,  $I_{4321} = 0_H$ ,  $I_0 = 0$ )

| To Output<br>From Input             |  | Slice<br>Position | Y              | C <sub>n+4</sub> | G̅, P̅ | Z (s) | N  | OVR | DB | WRITE | QIO <sub>0</sub><br>QIO <sub>3</sub> | SIO <sub>0</sub> | SIO <sub>3</sub> | SIO <sub>0</sub><br>Parity |
|-------------------------------------|--|-------------------|----------------|------------------|--------|-------|----|-----|----|-------|--------------------------------------|------------------|------------------|----------------------------|
| A, B Address<br>(Arith. Mode)       |  | MSS               | 99             | 88               | —      | —     | 99 | 112 | 49 | —     | —                                    | —                | 104              | —                          |
|                                     |  | IS, LSS           | 99             | 88               | 81     | —     | —  | —   | 49 | —     | —                                    | —                | 104              | —                          |
| DA, DB Inputs                       |  | MSS               | 63             | 60               | —      | —     | 64 | 89  | —  | —     | —                                    | —                | 70               | —                          |
|                                     |  | IS, LSS           | 63             | 60               | 49     | —     | —  | —   | —  | —     | —                                    | —                | 70               | —                          |
| E <sub>A</sub>                      |  | MSS               | 59             | 53               | —      | —     | 59 | 83  | —  | —     | —                                    | —                | 64               | —                          |
|                                     |  | IS, LSS           | 59             | 53               | 42     | —     | —  | —   | —  | —     | —                                    | —                | 64               | —                          |
| C <sub>n</sub>                      |  | MSS               | 40             | 30               | —      | —     | 40 | 58  | —  | —     | —                                    | —                | 46               | —                          |
|                                     |  | IS, LSS           | 40             | 30               | —      | —     | —  | —   | —  | —     | —                                    | —                | 46               | —                          |
| I <sub>0</sub>                      |  | MSS               | 95             | 91               | —      | 42    | 94 | 120 | —  | —     | *                                    | *                | 98*              | —                          |
|                                     |  | IS                | 95             | 91               | 72     | —     | —  | —   | —  | —     | *                                    | *                | 98*              | —                          |
|                                     |  | LSS               | 95             | 91               | 72     | —     | —  | —   | —  | 49    | *                                    | *                | 98*              | —                          |
| I <sub>4321</sub>                   |  | MSS               | 96             | 91               | —      | 42    | 94 | 118 | —  | —     | *                                    | *                | 98*              | —                          |
|                                     |  | IS                | 96             | 91               | 78     | —     | —  | —   | —  | —     | *                                    | *                | 98*              | —                          |
|                                     |  | LSS               | 96             | 91               | 78     | —     | —  | —   | —  | 49    | *                                    | *                | 98*              | —                          |
| I <sub>8765</sub>                   |  | MSS               | 85             | 78               | —      | 43    | 74 | 89  | —  | —     | *                                    | *                | 88*              | —                          |
|                                     |  | IS                | 85             | 78               | 62     | —     | —  | —   | —  | —     | *                                    | *                | 88*              | —                          |
|                                     |  | LSS               | 85             | 78               | 62     | —     | —  | —   | —  | 50    | *                                    | *                | 88*              | —                          |
| Clock                               |  | MSS               | 87             | 87               | —      | 53    | 88 | 108 | 37 | —     | 40                                   | —                | 92               | —                          |
|                                     |  | IS, LSS           | 87             | 87               | 71     | —     | —  | —   | 37 | —     | 40                                   | —                | 92               | —                          |
| Z                                   |  | MSS               | Z is an output |                  |        |       |    |     |    |       |                                      |                  |                  |                            |
|                                     |  | IS, LSS           | 73             | 66               | 54     | —     | —  | —   | —  | —     | —                                    | —                | 79               | —                          |
| I <sub>EN</sub>                     |  | Any               | —              | —                | —      | —     | —  | —   | —  | 22    | —                                    | —                | —                | —                          |
| SIO <sub>3</sub> , SIO <sub>0</sub> |  | Any               | 26             | —                | —      | —     | —  | —   | —  | —     | —                                    | —                | —                | —                          |

$$F = R + S + C_n \text{ if } Z = 0$$

$$S = R - 1 + C_n \text{ if } Z = 1$$

$$Z = F_3 \oplus R_3 \text{ (MSS) from previous cycle}$$

Notes: 1. A "\*" means the output is enabled or disabled by the input. See Tables C for enable and disable times. A number shown with a \* is the delay to correct data on an enabled output. A \* shown without a number means the output is disabled by the input or it is enabled but the delay to correct data is determined by something else.

2. A "—" means the delay path does not exist.

3. Data in bold face is different from Table A; other data is the same.

**Guaranteed Combinational Delays**  
 $T_C = -55^\circ \text{ to } +125^\circ\text{C}$ ,  $V_{CC} = 4.5\text{V to } 5.5\text{V}$   
**Standard Functions**

| From Input \ To Output  | Y   | $C_{n+4}$ | $\overline{G}, \overline{P}$ | Z (s) | N   | OVR | DB | WRITE | $QIO_0$<br>$QIO_3$ | $SIO_0$ | $SIO_3$ | $SIO_0$<br>Parity |
|-------------------------|-----|-----------|------------------------------|-------|-----|-----|----|-------|--------------------|---------|---------|-------------------|
| A Address (Arith. Mode) | 91  | 85        | 72                           | 116   | 92  | 115 | —  | —     | —                  | 89      | 98      | 120               |
| B Address               | 101 | 93        | 84                           | 126   | 102 | 118 | 52 | —     | —                  | 97      | 106     | 148               |
| A Address (Logic Mode)  | 92  | —         | 72                           | 117   | 93  | —   | —  | —     | —                  | 84      | 98      | 120               |
| B Address               | 86  | —         | 73                           | 111   | 89  | —   | 52 | —     | —                  | 86      | 92      | 125               |
| DA Inputs (Arith. Mode) | 64  | 62        | 51                           | 89    | 66  | 94  | —  | —     | —                  | 62      | 71      | 107               |
| DB Inputs               | 63  | 60        | 48                           | 88    | 63  | 89  | —  | —     | —                  | 64      | 68      | 100               |
| DA Inputs (Logic Mode)  | 65  | —         | 51                           | 90    | 67  | —   | —  | —     | —                  | 62      | 72      | 108               |
| DB Inputs               | 56  | —         | 32                           | 81    | 57  | —   | —  | —     | —                  | 52      | 63      | 100               |
| $\overline{EA}$         | 60  | 56        | 43                           | 85    | 60  | 87  | —  | —     | —                  | 58      | 64      | 103               |
| $C_n$                   | 40  | 30        | —                            | 65    | 40  | 59  | —  | —     | —                  | 38      | 46      | 69                |
| $I_0$                   | 52  | 50        | 36                           | 77    | 52  | 66  | —  | 53    | *                  | 51 *    | 58 *    | 96 *              |
| $I_{4321}$              | 72  | 69        | 73                           | 97    | 71  | 88  | —  | 53    | *                  | 66 *    | 75 *    | 111 *             |
| $I_{8765}$              | 44  | —         | —                            | 69    | —   | —   | —  | 50    | 65 *               | 42 *    | 45 *    | 42 *              |
| $\overline{IEN}$        | —   | —         | —                            | —     | —   | —   | —  | 24    | —                  | —       | —       | —                 |
| $SIO_3, SIO_0$          | 26  | —         | —                            | 51    | —   | —   | —  | —     | —                  | —       | 29      | 36                |
| Clock                   | 89  | 90        | 74                           | 114   | 89  | 116 | 39 | —     | 42                 | 91      | 96      | 110               |
| Y                       | —   | —         | —                            | 25    | —   | —   | —  | —     | —                  | —       | —       | —                 |
| $\overline{MSS}$        | 45  | —         | 44                           | 70    | 44  | 44  | —  | —     | —                  | 44      | 46      | 44                |

Note: A "\*" means the output is enabled or disabled by the input. See Tables C for enable and disable times. A number shown with a \* is the delay to correct data on an enabled output. A \* shown without a number means the output is disabled by the input or it is enabled but the delay to correct data is determined by something else.

$T_C = -55^\circ\text{C to } +125^\circ\text{C}$ ,  $V_{CC} = 4.5\text{V to } 5.5\text{V}$   
All Functions

CAUTION: READ NOTES TO TABLE B. NA = Not Applicable; no timing constraint.

| Input                        | With Respect to this Signal               | HIGH-to-LOW |        | LOW-to-HIGH |      | Comment                                       |
|------------------------------|---|-------------|--------|-------------|------|---|
|                              |   | Set-up      | Hold   | Set-up      | Hold |   |
| Y                            | Clock                                     | NA          | NA     | 23          | 3    | To store Y in RAM or Q                        |
| $\overline{\text{WE}}$ HIGH  | Clock                                     | 25          | Note 2 | Note 2      | 0    | To Prevent Writing                            |
| $\overline{\text{WE}}$ LOW   | Clock                                     | NA          | NA     | 35          | 0    | To Write into RAM                             |
| A, B as Sources              | Clock                                     | 38          | 3      | NA          | NA   | See Note 3                                    |
| B as a Destination           | Clock and $\overline{\text{WE}}$ both LOW | 6           | Note 4 | Note 4      | 3    | To Write Data only into the Correct B Address |
| $\text{QIO}_0, \text{QIO}_3$ | Clock                                     | NA          | NA     | 23          | 3    | To Shift Q                                    |
| $\text{I}_{8765}$            | Clock                                     | 24          | Note 5 | Note 5      | 0    |   |
| $\overline{\text{IEN}}$ HIGH | Clock                                     | 30          | Note 2 | Note 2      | 0    | To Prevent Writing into Q                     |
| $\overline{\text{IEN}}$ LOW  | Clock                                     | NA          | NA     | 30          | 0    | To Write into Q                               |
| $\text{I}_{43210}$           | Clock                                     | 24          | —      | 74          | 0    | See Note 6                                    |

Notes:

- For set-up times from all inputs not specified in Table IV B, the set-up time is computed by calculating the delay to stable Y outputs and then allowing the Y set-up time. Even if the RAM is not being loaded, the Y set-up time is necessary to set-up the Q register. All unspecified hold times are less than or equal to zero relative to the clock LOW-to-HIGH edge.
- $\overline{\text{WE}}$  controls writing into the RAM.  $\overline{\text{IEN}}$  controls writing into Q and, indirectly, controls  $\overline{\text{WE}}$  through the write output. To prevent writing,  $\overline{\text{IEN}}$  and  $\overline{\text{WE}}$  must be HIGH during the entire clock LOW time. They may go LOW after the clock has gone LOW to cause a write provided the  $\overline{\text{WE}}$  LOW and  $\overline{\text{IEN}}$  LOW set-up times are met. Having gone LOW, they should not be returned HIGH until after the clock has gone HIGH.
- A and B addresses must be set-up prior to clock LOW transition to capture data in latches at RAM output.
- Writing occurs when CP and  $\overline{\text{WE}}$  are both LOW. The B address should be stable during this entire period.
- Because  $\text{I}_{8765}$  control the writing or not writing of data into RAM and Q, they should be stable during the entire clock LOW time unless  $\overline{\text{IEN}}$  is HIGH, preventing writing.
- The set-up time prior to the clock LOW-to-HIGH transition occurs in parallel with the set-up time prior to the clock HIGH-to-LOW transition and the clock LOW time. The actual set-up time requirement on  $\text{I}_{43210}$ , relative to the clock LOW-to-HIGH transition, is the longer of (1) the set-up time prior to clock L  $\rightarrow$  H, and (2) the sum of the set-up time prior to clock H  $\rightarrow$  L and the clock LOW time.

TABLE IV C  
Guaranteed Enable/Disable Times  
 $T_C = -55^\circ\text{C to } +125^\circ\text{C}$ ,  $V_{CC} = 4.5\text{V to } 5.5\text{V}$   
All Functions

| From               | To                           | Enable | Disable |    |
|--------------------|------------------------------|--------|---------|----|
| OEY                | $\text{Y}_i$                 | 27     | 25      | ns |
| OEB                | $\text{DB}_i$                | 34     | 25      | ns |
| $\text{I}_8$       | $\text{SIO}_0, \text{SIO}_3$ |        | 25      | ns |
| $\text{I}_{8765}$  | $\text{QIO}_0, \text{QIO}_3$ |        | 60      | ns |
| $\text{I}_{43210}$ | $\text{QIO}_0, \text{QIO}_3$ | 70     | 60      | ns |
| LSS                | WRITE                        | 34     | 25      | ns |

Note:

- $C_L = 5.0\text{pF}$  for output disable tests. Measurement is made to a 0.5V change on the output.

TABLE IV D  
Guaranteed Clock and Write Pulse Characteristics  
 $T_C = -55^\circ\text{C to } +125^\circ\text{C}$ ,  $V_{CC} = 4.5\text{V to } 5.5\text{V}$   
All Functions

|  |    |    |
|--|----|----|
| Minimum Clock LOW Time                                       | 40 | ns |
| Minimum Clock HIGH Time                                      | 40 | ns |
| Minimum Time CP and $\overline{\text{WE}}$ both LOW to Write | 40 | ns |

TABLE IV E-0  
Guaranteed Combinational Delays  
 $T_C = -55^\circ\text{C}$  to  $+125^\circ\text{C}$ ,  $V_{CC} = 4.5\text{V}$  to  $5.5\text{V}$   
Unsigned Multiply Instruction  
( $I_{8765} = 0_H$ ,  $I_{4321} = 0_H$ ,  $I_0 = 0$ )

| To Output<br>From Input       | Slice<br>Position | Y   | $C_{n+4}$ | $\overline{G}, \overline{P}$ | Z (s) | N   | OVR | DB | WRITE | $QIO_0$<br>$QIO_3$ | $SIO_0$ | $SIO_3$ | $SIO_0$<br>Parity |
|-------------------------------|-------------------|-----|-----------|------------------------------|-------|-----|-----|----|-------|--------------------|---------|---------|-------------------|
| A, B Address<br>(Arith. Mode) | MSS               | 103 | 93        | —                            | —     | 102 | 118 | 52 | —     | —                  | 97      | —       | —                 |
|                               | IS, LSS           | 101 | 93        | 84                           | —     | —   | —   | 52 | —     | —                  | 97      | —       | —                 |
| DA, DB Inputs                 | MSS               | 66  | 62        | —                            | —     | 66  | 94  | —  | —     | —                  | 64      | —       | —                 |
|                               | IS, LSS           | 64  | 62        | 51                           | —     | —   | —   | —  | —     | —                  | 64      | —       | —                 |
| $\overline{EA}$               | MSS               | 74  | 56        | —                            | —     | 60  | 87  | —  | —     | —                  | 58      | —       | —                 |
|                               | IS, LSS           | 60  | 56        | 43                           | —     | —   | —   | —  | —     | —                  | 58      | —       | —                 |
| $C_n$                         | MSS               | 45  | 30        | —                            | —     | 40  | 59  | —  | —     | —                  | 38      | —       | —                 |
|                               | IS, LSS           | 40  | 30        | —                            | —     | —   | —   | —  | —     | —                  | 38      | —       | —                 |
| $I_0$                         | MSS               | 97  | 97        | —                            | —     | 87  | 106 | —  | —     | *                  | 71*     | *       | —                 |
|                               | IS                | 97  | 97        | 85                           | —     | —   | —   | —  | —     | *                  | 71*     | *       | —                 |
|                               | LSS               | 97  | 97        | 85                           | 42    | —   | —   | —  | 53    | *                  | 71*     | *       | —                 |
| $I_{4321}$                    | MSS               | 103 | 100       | —                            | —     | 94  | 111 | —  | —     | *                  | 73*     | *       | —                 |
|                               | IS                | 103 | 100       | 86                           | —     | —   | —   | —  | —     | *                  | 73*     | *       | —                 |
|                               | LSS               | 103 | 100       | 86                           | 43    | —   | —   | —  | 53    | *                  | 73*     | *       | —                 |
| $I_{8765}$                    | MSS               | 102 | 93        | —                            | —     | 76  | 89  | —  | —     | *                  | 75*     | *       | —                 |
|                               | IS                | 102 | 93        | 92                           | —     | —   | —   | —  | —     | *                  | 75*     | *       | —                 |
|                               | LSS               | 102 | 93        | 92                           | 51    | —   | —   | —  | 50    | *                  | 75      | *       | —                 |
| Clock                         | MSS               | 94  | 90        | —                            | —     | 89  | 116 | 39 | —     | 42                 | 91      | —       | —                 |
|                               | IS, LSS           | 89  | 90        | 74                           | 57    | —   | —   | 39 | —     | 42                 | 91      | —       | —                 |
| Z                             | MSS               | 76  | 65        | —                            | —     | 70  | 81  | —  | —     | —                  | 72      | —       | —                 |
|                               | IS                | 76  | 65        | 49                           | —     | —   | —   | —  | —     | —                  | 72      | —       | —                 |
| IEN                           | Any               | —   | —         | —                            | —     | —   | —   | —  | 24    | —                  | —       | —       | —                 |
| $SIO_3, SIO_0$                | Any               | 26  | —         | —                            | —     | —   | —   | —  | —     | —                  | —       | —       | —                 |

$$F = S + C_n \text{ if } Z = 0$$

$$S + R + C_n \text{ if } Z = 1$$

$$Y_3 = C_{n+4} \text{ (MSS)}$$

$$Z = Q_0 \text{ (LSS)}$$

- Notes: 1. A "\*" means the output is enabled or disabled by the input. See Tables C for enable and disable times. A number shown with a \* is the delay to correct data on an enabled output. A \* shown without a number means the output is disabled by the input or it is enabled but the delay to correct data is determined by something else.
2. A "—" means the delay path does not exist.
3. Data in bold face is different from Table A; other data is the same.



TABLE IV E-2  
Guaranteed Combinational Delays  
 $T_C = -55^\circ\text{C to } +125^\circ\text{C}$ ,  $V_{CC} = 4.5\text{V to } 5.5\text{V}$   
Two's Complement Multiply Instruction  
( $I_{8765} = 2_H$ ,  $I_{4321} = 0_H$ ,  $I_0 = 0$ )

| To Output<br>From Input             | Slice<br>Position | Y   | $C_{n+4}$ | $\overline{G}, \overline{P}$ | Z (s) | N   | OVR | DB | WRITE | QIO <sub>0</sub><br>QIO <sub>3</sub> | SIO <sub>0</sub> | SIO <sub>3</sub> | SIO <sub>0</sub><br>Parity |
|-------------------------------------|-------------------|-----|-----------|------------------------------|-------|-----|-----|----|-------|--------------------------------------|------------------|------------------|----------------------------|
| A, B Address<br>(Arith. Mode)       | MSS               | 113 | 93        | —                            | —     | 102 | 118 | 52 | —     | —                                    | 97               | —                | —                          |
|                                     | IS, LSS           | 101 | 93        | 84                           | —     | —   | —   | 52 | —     | —                                    | 97               | —                | —                          |
| DA, DB Inputs                       | MSS               | 78  | 62        | —                            | —     | 66  | 94  | —  | —     | —                                    | 64               | —                | —                          |
|                                     | IS, LSS           | 64  | 62        | 51                           | —     | —   | —   | —  | —     | —                                    | 64               | —                | —                          |
| $\overline{EA}$                     | MSS               | 85  | 56        | —                            | —     | 60  | 87  | —  | —     | —                                    | 58               | —                | —                          |
|                                     | IS, LSS           | 60  | 56        | 43                           | —     | —   | —   | —  | —     | —                                    | 58               | —                | —                          |
| $C_n$                               | MSS               | 58  | 30        | —                            | —     | 40  | 59  | —  | —     | —                                    | 38               | —                | —                          |
|                                     | IS, LSS           | 40  | 30        | —                            | —     | —   | —   | —  | —     | —                                    | 38               | —                | —                          |
| $I_0$                               | MSS               | 105 | 97        | —                            | —     | 89  | 102 | —  | —     | *                                    | 71*              | *                | —                          |
|                                     | IS                | 105 | 97        | 81                           | —     | —   | —   | —  | —     | *                                    | 71*              | *                | —                          |
|                                     | LSS               | 105 | 97        | 81                           | 42    | —   | —   | —  | 53    | *                                    | 71*              | *                | —                          |
| $I_{4321}$                          | MSS               | 112 | 98        | —                            | —     | 94  | 111 | —  | —     | *                                    | 75*              | *                | —                          |
|                                     | IS                | 112 | 98        | 85                           | —     | —   | —   | —  | —     | *                                    | 75*              | *                | —                          |
|                                     | LSS               | 112 | 98        | 85                           | 43    | —   | —   | —  | 53    | *                                    | 75*              | *                | —                          |
| $I_{8765}$                          | MSS               | 99  | 86        | —                            | —     | 78  | 100 | —  | —     | *                                    | 74*              | *                | —                          |
|                                     | IS                | 99  | 86        | 84                           | —     | —   | —   | —  | —     | *                                    | 74*              | *                | —                          |
|                                     | LSS               | 99  | 86        | 84                           | 48    | —   | —   | —  | 50    | *                                    | 74*              | *                | —                          |
| Clock                               | MSS               | 107 | 90        | —                            | —     | 89  | 116 | 39 | —     | 42                                   | 91               | —                | —                          |
|                                     | IS, LSS           | 89  | 90        | 74                           | 57    | —   | —   | 39 | —     | 42                                   | 91               | —                | —                          |
| Z                                   | MSS               | 90  | 65        | —                            | —     | 70  | 81  | —  | —     | —                                    | 72               | —                | —                          |
|                                     | IS                | 90  | 65        | 48                           | —     | —   | —   | —  | —     | —                                    | 72               | —                | —                          |
| $\overline{IEN}$                    | Any               | —   | —         | —                            | —     | —   | —   | —  | 24    | —                                    | —                | —                | —                          |
| SIO <sub>3</sub> , SIO <sub>0</sub> | Any               | 26  | —         | —                            | —     | —   | —   | —  | —     | —                                    | —                | —                | —                          |

$$F = S + C_n \text{ if } Z = 0$$

$$S + R + C_n \text{ if } Z = 1$$

$$Y_3 = F_3 \oplus \text{OVR (MSS)}$$

$$Z = Q_0 \text{ (LSS)}$$

Notes: 1. A "\*" means the output is enabled or disabled by the input. See Tables C for enable and disable times. A number shown with a \* is the delay to correct data on an enabled output. A \* shown without a number means the output is disabled by the input or it is enabled but the delay to correct data is determined by something else.

2. A "—" means the delay path does not exist.

3. Data in bold face is different from Table A; other data is the same.

Increment by One or Two Instruction

(I<sub>8765</sub> = 4H, I<sub>4321</sub> = 0H, I<sub>0</sub> = 0)

| To Output<br>From Input             | Slice<br>Position | Y              | C <sub>n+4</sub> | $\overline{G}, \overline{P}$ | Z (s)     | N         | OVR       | DB | WRITE | QIO <sub>0</sub><br>QIO <sub>3</sub> | SIO <sub>0</sub> | SIO <sub>3</sub> | SIO <sub>0</sub><br>Parity |
|-------------------------------------|-------------------|----------------|------------------|------------------------------|-----------|-----------|-----------|----|-------|--------------------------------------|------------------|------------------|----------------------------|
| A, B Address<br>(Arith. Mode)       | MSS               | 101            | 93               | —                            | 126       | 102       | 118       | 52 | —     | —                                    | —                | —                | 148                        |
|                                     | IS, LSS           | 101            | 93               | 84                           | 126       | —         | —         | 52 | —     | —                                    | —                | —                | 148                        |
| DA, DB Inputs                       | MSS               | 64             | 62               | —                            | 89        | 66        | 94        | —  | —     | —                                    | —                | —                | 107                        |
|                                     | IS, LSS           | 64             | 62               | 51                           | 89        | —         | —         | —  | —     | —                                    | —                | —                | 107                        |
| $\overline{EA}$                     | MSS               | —              | —                | —                            | —         | —         | —         | —  | —     | —                                    | —                | —                | —                          |
|                                     | IS, LSS           | —              | —                | —                            | —         | —         | —         | —  | —     | —                                    | —                | —                | —                          |
| C <sub>n</sub>                      | MSS               | 40             | 30               | —                            | 65        | 40        | 59        | —  | —     | —                                    | —                | —                | 69                         |
|                                     | IS, LSS           | 40             | 30               | —                            | 65        | 40        | 59        | —  | —     | —                                    | —                | —                | 69                         |
| I <sub>0</sub>                      | MSS               | <b>73</b>      | <b>61</b>        | —                            | <b>98</b> | <b>72</b> | <b>87</b> | —  | —     | *                                    | *                | *                | <b>110*</b>                |
|                                     | IS                | <b>73</b>      | <b>61</b>        | <b>62</b>                    | <b>98</b> | —         | —         | —  | —     | *                                    | *                | *                | <b>110*</b>                |
|                                     | LSS               | <b>73</b>      | <b>61</b>        | <b>62</b>                    | <b>98</b> | —         | —         | —  | 53    | *                                    | *                | *                | <b>110*</b>                |
| I <sub>4321</sub>                   | MSS               | <b>72</b>      | <b>61</b>        | —                            | <b>97</b> | <b>74</b> | <b>87</b> | —  | —     | *                                    | *                | *                | <b>110*</b>                |
|                                     | IS                | <b>72</b>      | <b>61</b>        | <b>62</b>                    | <b>97</b> | —         | —         | —  | —     | *                                    | *                | *                | <b>110*</b>                |
|                                     | LSS               | <b>72</b>      | <b>61</b>        | <b>62</b>                    | <b>97</b> | —         | —         | —  | 53    | *                                    | *                | *                | <b>110*</b>                |
| I <sub>8765</sub>                   | MSS               | <b>72</b>      | <b>61</b>        | —                            | <b>97</b> | <b>74</b> | <b>87</b> | —  | —     | *                                    | *                | *                | <b>110*</b>                |
|                                     | IS                | <b>72</b>      | <b>61</b>        | <b>62</b>                    | <b>97</b> | —         | —         | —  | —     | *                                    | *                | *                | <b>110*</b>                |
|                                     | LSS               | <b>72</b>      | <b>61</b>        | <b>62</b>                    | <b>97</b> | —         | —         | —  | 50    | *                                    | *                | *                | <b>110*</b>                |
| Clock                               | MSS               | 89             | 90               | 74                           | 114       | 89        | 116       | 39 | —     | 42                                   | —                | —                | 110                        |
|                                     | IS, LSS           | 89             | 90               | 74                           | 114       | 89        | 116       | 39 | —     | 42                                   | —                | —                | 110                        |
| Z                                   | MSS               | Z is an output |                  |                              |           |           |           |    |       |                                      |                  |                  |                            |
|                                     | IS, LSS           | Z is an output |                  |                              |           |           |           |    |       |                                      |                  |                  |                            |
| Y                                   | Any               | —              | —                | —                            | 25        | —         | —         | —  | —     | —                                    | —                | —                | —                          |
| $\overline{IEN}$                    | Any               | —              | —                | —                            | —         | —         | —         | —  | 24    | —                                    | —                | —                | —                          |
| SIO <sub>3</sub> , SIO <sub>0</sub> | Any               | 26             | —                | —                            | —         | —         | —         | —  | —     | —                                    | —                | —                | —                          |

$$F = S + 1 + C_n$$

- Notes: 1. A "\*" means the output is enabled or disabled by the input. See Tables C for enable and disable times. A number shown with a \* is the delay to correct data on an enabled output. A \* shown without a number means the output is disabled by the input or it is enabled but the delay to correct data is determined by something else.
2. A "—" means the delay path does not exist.
3. Data in bold face is different from Table A; other data is the same.

**Guaranteed Combinational Delays**  
 $T_C = -55^\circ\text{C to } +125^\circ\text{C}, V_{CC} = 4.5\text{V to } 5.5\text{V}$   
**Sign Magnitude/Two's Complement Conversion**  
 $(I_{8765} = 5_H, I_{4321} = 0_H, I_0 = 0)$

| To Output<br>From Input             | Slice<br>Position | Y              | $C_{n+4}$ | $\overline{G}, \overline{P}$ | Z (s)     | N          | OVR        | DB | WRITE | QIO <sub>0</sub><br>QIO <sub>3</sub> | SIO <sub>0</sub> | SIO <sub>3</sub> | SIO <sub>0</sub><br>Parity |
|-------------------------------------|-------------------|----------------|-----------|------------------------------|-----------|------------|------------|----|-------|--------------------------------------|------------------|------------------|----------------------------|
| A, B Address<br>(Arith. Mode)       | MSS               | <b>143</b>     | 93        | —                            | <b>78</b> | <b>143</b> | 118        | 52 | —     | —                                    | —                | —                | 148                        |
|                                     | IS, LSS           | 101            | 93        | 84                           | —         | —          | —          | 52 | —     | —                                    | —                | —                | 148                        |
| DA, DB Inputs                       | MSS               | <b>103</b>     | 62        | —                            | <b>40</b> | <b>103</b> | 94         | —  | —     | —                                    | —                | —                | 107                        |
|                                     | IS, LSS           | 64             | 62        | 51                           | —         | —          | —          | —  | —     | —                                    | —                | —                | 107                        |
| $\overline{EA}$                     | MSS               | —              | —         | —                            | —         | —          | —          | —  | —     | —                                    | —                | —                | —                          |
|                                     | IS, LSS           | —              | —         | —                            | —         | —          | —          | —  | —     | —                                    | —                | —                | —                          |
| $C_n$                               | MSS               | <b>83</b>      | 30        | —                            | —         | <b>83</b>  | 59         | —  | —     | —                                    | —                | —                | 69                         |
|                                     | IS, LSS           | 40             | 30        | —                            | —         | —          | —          | —  | —     | —                                    | —                | —                | 69                         |
| $I_0$                               | MSS               | <b>102</b>     | <b>80</b> | —                            | <b>50</b> | <b>100</b> | <b>115</b> | —  | —     | *                                    | *                | *                | <b>132*</b>                |
|                                     | IS                | <b>102</b>     | <b>80</b> | <b>70</b>                    | —         | —          | —          | —  | —     | *                                    | *                | *                | <b>132*</b>                |
|                                     | LSS               | <b>102</b>     | <b>80</b> | <b>70</b>                    | —         | —          | —          | 53 | —     | *                                    | *                | *                | <b>132*</b>                |
| $I_{4321}$                          | MSS               | <b>102</b>     | <b>80</b> | —                            | <b>50</b> | <b>102</b> | <b>110</b> | —  | —     | *                                    | *                | *                | <b>132*</b>                |
|                                     | IS                | <b>102</b>     | <b>80</b> | <b>75</b>                    | —         | —          | —          | —  | —     | *                                    | *                | *                | <b>132*</b>                |
|                                     | LSS               | <b>102</b>     | <b>80</b> | <b>75</b>                    | —         | —          | —          | 53 | —     | *                                    | *                | *                | <b>132*</b>                |
| $I_{8765}$                          | MSS               | <b>103</b>     | <b>80</b> | —                            | <b>50</b> | <b>100</b> | <b>112</b> | —  | —     | *                                    | *                | *                | <b>142*</b>                |
|                                     | IS                | <b>103</b>     | <b>80</b> | <b>65</b>                    | —         | —          | —          | —  | —     | *                                    | *                | *                | <b>142*</b>                |
|                                     | LSS               | <b>103</b>     | <b>80</b> | <b>65</b>                    | —         | —          | —          | 50 | —     | *                                    | *                | *                | <b>142*</b>                |
| Clock                               | MSS               | <b>120</b>     | 90        | —                            | <b>61</b> | <b>120</b> | 116        | 39 | —     | —                                    | —                | —                | 110                        |
|                                     | IS, LSS           | 89             | 90        | 74                           | —         | —          | —          | 39 | —     | —                                    | —                | —                | 110                        |
| Z                                   | MSS               | Z is an output |           |                              |           |            |            |    |       |                                      |                  |                  |                            |
|                                     | IS, LSS           | <b>76</b>      | <b>61</b> | <b>51</b>                    | —         | —          | —          | —  | —     | —                                    | —                | —                | <b>118</b>                 |
| $\overline{IEN}$                    | Any               | —              | —         | —                            | —         | —          | —          | —  | 24    | —                                    | —                | —                | —                          |
| SIO <sub>3</sub> , SIO <sub>0</sub> | Any               | 26             | —         | —                            | —         | —          | —          | —  | —     | —                                    | —                | —                | —                          |

$F = S + C_n$  if  $Z = 0$   
 $\overline{S} + C_n$  if  $Z = 1$   
 $Y_3 = S_3 \oplus F_3$  (MSS)  
 $Z = S_3$  (MSS)

- Notes: 1. A "\*" means the output is enabled or disabled by the input. See Tables C for enable and disable times. A number shown with a \* is the delay to correct data on an enabled output. A \* shown without a number means the output is disabled by the input or it is enabled but the delay to correct data is determined by something else.
2. A "—" means the delay path does not exist.
3. Data in bold face is different from Table A; other data is the same.

TABLE IV E-6  
Guaranteed Combinational Delays  
 $T_C = -55^\circ\text{C to } +125^\circ\text{C}$ ,  $V_{CC} = 4.5\text{V to } 5.5\text{V}$   
Two's Complement Multiply, Last Cycle  
( $I_{8765} = 6_H$ ,  $I_{4321} = 0_H$ ,  $I_0 = 0$ )

| To Output<br>From Input       | Slice<br>Position | Y   | $C_{n+4}$ | $\bar{G}, \bar{P}$ | Z (s) | N   | OVR | DB | WRITE | $QIO_0$<br>$QIO_3$ | $SIO_0$ | $SIO_3$ | $SIO_0$<br>Parity |
|-------------------------------|-------------------|-----|-----------|--------------------|-------|-----|-----|----|-------|--------------------|---------|---------|-------------------|
| A, B Address<br>(Arith. Mode) | MSS               | 121 | 93        | —                  | —     | 102 | 118 | 52 | —     | —                  | 97      | —       | —                 |
|                               | IS, LSS           | 101 | 93        | 84                 | —     | —   | —   | 52 | —     | —                  | 97      | —       | —                 |
| DA, DB Inputs                 | MSS               | 88  | 62        | —                  | —     | 66  | 94  | —  | —     | —                  | 64      | —       | —                 |
|                               | IS, LSS           | 64  | 62        | 51                 | —     | —   | —   | —  | —     | —                  | 64      | —       | —                 |
| $\bar{E}A$                    | MSS               | 96  | 56        | —                  | —     | 60  | 87  | —  | —     | —                  | 58      | —       | —                 |
|                               | IS, LSS           | 60  | 56        | 43                 | —     | —   | —   | —  | —     | —                  | 58      | —       | —                 |
| $C_n$                         | MSS               | 64  | 30        | —                  | —     | 40  | 59  | —  | —     | —                  | 38      | —       | —                 |
|                               | IS, LSS           | 40  | 30        | —                  | —     | —   | —   | —  | —     | —                  | 38      | —       | —                 |
| $I_0$                         | MSS               | 118 | 102       | —                  | —     | 97  | 126 | —  | —     | *                  | 102*    | *       | —                 |
|                               | IS                | 118 | 102       | 87                 | —     | —   | —   | —  | —     | *                  | 102*    | *       | —                 |
|                               | LSS               | 118 | 102       | 87                 | 42    | —   | —   | —  | 53    | *                  | 102*    | *       | —                 |
| $I_{4321}$                    | MSS               | 120 | 101       | —                  | —     | 97  | 127 | —  | —     | *                  | 101*    | *       | —                 |
|                               | IS                | 120 | 101       | 86                 | —     | —   | —   | —  | —     | *                  | 101*    | *       | —                 |
|                               | LSS               | 120 | 101       | 86                 | 43    | —   | —   | —  | 53    | *                  | 101*    | *       | —                 |
| $I_{8765}$                    | MSS               | 105 | 98        | —                  | —     | 88  | 115 | —  | —     | *                  | 102*    | *       | —                 |
|                               | IS                | 105 | 98        | 86                 | —     | —   | —   | —  | —     | *                  | 102*    | *       | —                 |
|                               | LSS               | 105 | 98        | 86                 | 51    | —   | —   | —  | 50    | *                  | 102*    | *       | —                 |
| Clock                         | MSS               | 110 | 90        | —                  | —     | 89  | 116 | 39 | —     | 42                 | 91      | —       | —                 |
|                               | IS, LSS           | 89  | 90        | 74                 | 58    | —   | —   | 39 | —     | 42                 | 91      | —       | —                 |
| Z                             | MSS               | 92  | 67        | —                  | —     | 80  | 103 | —  | —     | —                  | 72      | —       | —                 |
|                               | IS                | 92  | 67        | 53                 | —     | —   | —   | —  | —     | —                  | 72      | —       | —                 |
| $\bar{I}EN$                   | Any               | —   | —         | —                  | —     | —   | —   | —  | 24    | —                  | —       | —       | —                 |
| $SIO_3, SIO_0$                | Any               | 26  | —         | —                  | —     | —   | —   | —  | —     | —                  | —       | —       | —                 |

$$F = S + C_n \text{ if } Z = 0$$

$$S - R - 1 + C_n \text{ is } Z = 1$$

$$Y_3 = (OVR \oplus F_3) \text{ MSS}$$

$$Z = Q_0 \text{ (LSS)}$$

Notes: 1. A "\*" means the output is enabled or disabled by the input. See Tables C for enable and disable times. A number shown with a \* is the delay to correct data on an enabled output. A \* shown without a number means the output is disabled by the input or it is enabled but the delay to correct data is determined by something else.

2. A "—" means the delay path does not exist.

3. Data in bold face is different from Table A; other data is the same.



TABLE IV E-8  
Guaranteed Combinational Delays  
 $T_C = -55^\circ\text{C}$  to  $+125^\circ\text{C}$ ,  $V_{CC} = 4.5\text{V}$  to  $5.5\text{V}$   
Single-Length Normalize Instruction  
( $I_{8765} = 8_H$ ,  $I_{4321} = 0_H$ ,  $I_0 = 0$ )

| To Output<br>From Input       | Slice<br>Position | Y              | $C_{n+4}$ | $\overline{G}, \overline{P}$ | Z (s) | N   | OVR | DB | WRITE | $QIO_0$<br>$QIO_3$ | $SIO_0$ | $SIO_3$ | $SIO_0$<br>Parity |
|-------------------------------|-------------------|----------------|-----------|------------------------------|-------|-----|-----|----|-------|--------------------|---------|---------|-------------------|
| A, B Address<br>(Arith. Mode) | MSS               | 101            | 93        | —                            | —     | 102 | 118 | 52 | —     | —                  | —       | —       | —                 |
|                               | IS, LSS           | 101            | 93        | 84                           | —     | —   | —   | 52 | —     | —                  | —       | —       | —                 |
| DA, DB Inputs                 | MSS               | 63             | 60        | —                            | —     | 66  | 94  | —  | —     | —                  | —       | —       | —                 |
|                               | IS, LSS           | 63             | 60        | 51                           | —     | —   | —   | —  | —     | —                  | —       | —       | —                 |
| $\overline{EA}$               | MSS               | 60             | 56        | —                            | —     | 60  | 87  | —  | —     | —                  | —       | —       | —                 |
|                               | IS, LSS           | 60             | 56        | 43                           | —     | —   | —   | —  | —     | —                  | —       | —       | —                 |
| $C_n$                         | MSS               | 40             | 30        | —                            | —     | 40  | 59  | —  | —     | —                  | —       | —       | —                 |
|                               | IS, LSS           | 40             | 30        | —                            | —     | —   | —   | —  | —     | —                  | —       | —       | —                 |
| $I_0$                         | MSS               | 72             | 60        | —                            | 34    | 43  | 42  | —  | —     | *                  | *       | 78*     | —                 |
|                               | IS                | 72             | 60        | 59                           | 34    | —   | —   | —  | —     | *                  | *       | 78*     | —                 |
|                               | LSS               | 72             | 60        | 59                           | 34    | —   | —   | —  | 53    | *                  | *       | 78*     | —                 |
| $I_{4321}$                    | MSS               | 72             | 60        | —                            | 38    | 48  | 47  | —  | —     | *                  | *       | 78*     | —                 |
|                               | IS                | 72             | 60        | 60                           | 38    | —   | —   | —  | —     | *                  | *       | 78*     | —                 |
|                               | LSS               | 72             | 60        | 60                           | 38    | —   | —   | —  | 53    | *                  | *       | 78*     | —                 |
| $I_{8765}$                    | MSS               | 67             | 58        | —                            | 50    | 53  | 47  | —  | —     | *                  | *       | 72*     | —                 |
|                               | IS                | 67             | 58        | 42                           | 50    | —   | —   | —  | —     | *                  | *       | 72*     | —                 |
|                               | LSS               | 67             | 58        | 42                           | 50    | —   | —   | —  | 50    | *                  | *       | 72*     | —                 |
| Clock                         | MSS               | 89             | 53        | —                            | 53    | 49  | 49  | 39 | —     | 42                 | —       | 96      | —                 |
|                               | IS, LSS           | 89             | 90        | 74                           | 53    | —   | —   | 39 | —     | 42                 | —       | 96      | —                 |
| Z                             | MSS               | Z is an output |           |                              |       |     |     |    |       |                    |         |         |                   |
|                               | IS, LSS           | Z is an output |           |                              |       |     |     |    |       |                    |         |         |                   |
| $\overline{IEN}$              | Any               | —              | —         | —                            | —     | —   | —   | —  | 24    | —                  | —       | —       | —                 |
| $SIO_3, SIO_0$                | Any               | 26             | —         | —                            | —     | —   | —   | —  | —     | —                  | —       | —       | —                 |

$$F = S + C_n$$

$$C_{n+4} = Q_3 \oplus Q_2 \text{ (MSS)}$$

$$OVR = Q_2 \oplus Q_1 \text{ (MSS)}$$

$$N = Q_3 \text{ (MSS)}$$

$$Z = Q_0 Q_1 Q_2 Q_3$$

Notes: 1. A "\*" means the output is enabled or disabled by the input. See Tables C for enable and disable times. A number shown with a \* is the delay to correct data on an enabled output. A \* shown without a number means the output is disabled by the input or it is enabled but the delay to correct data is determined by something else.

2. A "—" means the delay path does not exist.

3. Data in bold face is different from Table A; other data is the same.

$T_C = -55^\circ\text{C}$  to  $+125^\circ\text{C}$ ,  $V_{CC} = 4.5\text{V}$  to  $5.5\text{V}$   
First Divide Operation (Double Length Normalize)  
( $I_{8765} = A_H$ ,  $I_{4321} = 0_H$ ,  $I_0 = 0$ )

| To Output<br>From Input             | Slice<br>Position | Y              | C <sub>n+4</sub> | G, P | Z (s) | N   | OVR | DB | WRITE | QIO <sub>0</sub><br>QIO <sub>3</sub> | SIO <sub>0</sub> | SIO <sub>3</sub> | SIO <sub>0</sub><br>Parity |
|-------------------------------------|-------------------|----------------|------------------|------|-------|-----|-----|----|-------|--------------------------------------|------------------|------------------|----------------------------|
| A, B Address<br>(Arith. Mode)       | MSS               | 101            | 122              | —    | 96    | 100 | 112 | 52 | —     | —                                    | —                | 130              | —                          |
|                                     | IS, LSS           | 101            | 93               | 84   | —     | —   | —   | 52 | —     | —                                    | —                | 106              | —                          |
| DA, DB Inputs                       | MSS               | 64             | 80               | —    | 63    | 65  | 72  | —  | —     | —                                    | —                | 84               | —                          |
|                                     | IS, LSS           | 64             | 62               | 51   | —     | —   | —   | —  | —     | —                                    | —                | 71               | —                          |
| EA                                  | MSS               | —              | —                | —    | —     | —   | —   | —  | —     | —                                    | —                | 80               | —                          |
|                                     | IS, LSS           | —              | —                | —    | —     | —   | —   | —  | —     | —                                    | —                | 46               | —                          |
| C <sub>n</sub>                      | MSS               | 40             | 57               | —    | 48    | 48  | 55  | —  | —     | —                                    | —                | 68               | —                          |
|                                     | IS, LSS           | 40             | 30               | —    | —     | —   | —   | —  | —     | —                                    | —                | 46               | —                          |
| I <sub>0</sub>                      | MSS               | 71             | 98               | —    | 85    | 72  | 91  | —  | —     | *                                    | *                | 101*             | —                          |
|                                     | IS                | 71             | 98               | 61   | 85    | —   | —   | —  | —     | *                                    | *                | 101*             | —                          |
|                                     | LSS               | 71             | 98               | 61   | 85    | —   | —   | —  | 53    | *                                    | *                | 101*             | —                          |
| I <sub>4321</sub>                   | MSS               | 71             | 98               | —    | 85    | 76  | 91  | —  | —     | *                                    | *                | 101*             | —                          |
|                                     | IS                | 71             | 98               | 61   | 85    | —   | —   | —  | —     | *                                    | *                | 101*             | —                          |
|                                     | LSS               | 71             | 98               | 61   | 85    | —   | —   | —  | 53    | *                                    | *                | 101*             | —                          |
| I <sub>8765</sub>                   | MSS               | 71             | 98               | —    | 85    | 76  | 91  | —  | —     | *                                    | *                | 101*             | —                          |
|                                     | IS                | 71             | 98               | 61   | 85    | —   | —   | —  | —     | *                                    | *                | 101*             | —                          |
|                                     | LSS               | 71             | 98               | 61   | 85    | —   | —   | —  | 50    | *                                    | *                | 101*             | —                          |
| Clock                               | MSS               | 89             | 113              | —    | 90    | 87  | 98  | 39 | —     | 42                                   | —                | 114              | —                          |
|                                     | IS, LSS           | 89             | 90               | 74   | 90    | —   | —   | 39 | —     | 42                                   | —                | 96               | —                          |
| Z                                   | MSS               | Z is an output |                  |      |       |     |     |    |       |                                      |                  |                  |                            |
|                                     | IS                | Z is an output |                  |      |       |     |     |    |       |                                      |                  |                  |                            |
| EN                                  | Any               | —              | —                | —    | —     | —   | —   | —  | 24    | —                                    | —                | —                | —                          |
| SIO <sub>3</sub> , SIO <sub>0</sub> | Any               | 26             | —                | —    | —     | —   | —   | —  | —     | —                                    | —                | —                | —                          |

$$F = S + C_n$$

$$N = F_3 \text{ (MSS)}$$

$$S_{IO_3} = F_3 \oplus R_3 \text{ (MSS)}$$

$$Z = \overline{Q_0}Q_1\overline{Q_2}Q_3F_0F_1F_2F_3$$

$$C_{n+4} = F_3 \oplus F_2 \text{ (MSS)}$$

$$OVR = F_2 \oplus F_1 \text{ (MSS)}$$

Notes: 1. A "\*" means the output is enabled or disabled by the input. See Tables C for enable and disable times. A number shown with a \* is the delay to correct data on an enabled output. A \* shown without a number means the output is disabled by the input or it is enabled but the delay to correct data is determined by something else.

2. A "—" means the delay path does not exist.

3. Data in bold face is different from Table A; other data is the same.

TABLE IV E-C  
Guaranteed Combinational Delays  
 $T_C = -55^\circ\text{C to } +125^\circ\text{C}$ ,  $V_{CC} = 4.5\text{V to } 5.5\text{V}$   
Two's Complement Divide Operation  
( $I_{8765} = C_H$ ,  $I_{4321} = 0_H$ ,  $I_0 = 0$ )

| To Output<br>From Input       | Slice<br>Position | Y              | $C_{n+4}$ | $\bar{G}, \bar{P}$ | Z (s) | N   | OVR | DB | WRITE | $QIO_0$<br>$QIO_3$ | $SIO_0$ | $SIO_3$ | $SIO_0$<br>Parity |
|-------------------------------|-------------------|----------------|-----------|--------------------|-------|-----|-----|----|-------|--------------------|---------|---------|-------------------|
| A, B Address<br>(Arith. Mode) | MSS               | 101            | 93        | —                  | —     | 102 | 118 | 52 | —     | —                  | —       | 112     | —                 |
|                               | IS, LSS           | 101            | 93        | 84                 | —     | —   | —   | 52 | —     | —                  | —       | 106     | —                 |
| DA, DB Inputs                 | MSS               | 64             | 62        | —                  | —     | 66  | 94  | —  | —     | —                  | —       | 88      | —                 |
|                               | IS, LSS           | 64             | 62        | 51                 | —     | —   | —   | —  | —     | —                  | —       | 71      | —                 |
| $\bar{E}A$                    | MSS               | 60             | 56        | —                  | —     | 60  | 87  | —  | —     | —                  | —       | 96      | —                 |
|                               | IS, LSS           | 60             | 56        | 43                 | —     | —   | —   | —  | —     | —                  | —       | 64      | —                 |
| $C_n$                         | MSS               | 40             | 30        | —                  | —     | 40  | 59  | —  | —     | —                  | —       | 64      | —                 |
|                               | IS, LSS           | 40             | 30        | —                  | —     | —   | —   | —  | —     | —                  | —       | 46      | —                 |
| $I_0$                         | MSS               | 95             | 96        | —                  | 42    | 98  | 127 | —  | —     | *                  | *       | 113*    | —                 |
|                               | IS                | 95             | 96        | 77                 | —     | —   | —   | —  | —     | *                  | *       | 113*    | —                 |
|                               | LSS               | 95             | 96        | 77                 | —     | —   | —   | 53 | —     | *                  | *       | 113*    | —                 |
| $I_{4321}$                    | MSS               | 96             | 96        | —                  | 42    | 97  | 124 | —  | —     | *                  | *       | 114*    | —                 |
|                               | IS                | 96             | 97        | 82                 | —     | —   | —   | —  | —     | *                  | *       | 114*    | —                 |
|                               | LSS               | 96             | 97        | 82                 | —     | —   | —   | 53 | —     | *                  | *       | 114*    | —                 |
| $I_{8765}$                    | MSS               | 98             | 97        | —                  | 44    | 102 | 112 | —  | —     | *                  | *       | 119*    | —                 |
|                               | IS                | 98             | 97        | 64                 | —     | —   | —   | —  | —     | *                  | *       | 119*    | —                 |
|                               | LSS               | 98             | 97        | 64                 | —     | —   | —   | 50 | —     | *                  | *       | 119*    | —                 |
| Clock                         | MSS               | 89             | 90        | —                  | 58    | 89  | 116 | 39 | —     | 42                 | —       | 136     | —                 |
|                               | IS, LSS           | 89             | 90        | 74                 | —     | —   | —   | 39 | —     | 42                 | —       | 96      | —                 |
| Z                             | MSS               | Z is an output |           |                    |       |     |     |    |       |                    |         |         |                   |
|                               | IS, LSS           | 71             | 68        | 56                 | —     | —   | —   | —  | —     | —                  | —       | 81      | —                 |
| $\bar{I}EN$                   | Any               | —              | —         | —                  | —     | —   | —   | —  | 24    | —                  | —       | —       | —                 |
| $SIO_3, SIO_0$                | Any               | 26             | —         | —                  | —     | —   | —   | —  | —     | —                  | —       | —       | —                 |

$$F = S + R + C_n \text{ if } Z = 0$$

$$S - R - 1 + C_n \text{ if } Z = 1$$

$$SIO_3 = F_3 \oplus R_3 \text{ (MSS)}$$

$$Z = F_3 \oplus R_3 \text{ (MSS) from previous cycle}$$

Notes: 1. A "\*" means the output is enabled or disabled by the input. See Tables C for enable and disable times. A number shown with a \* is the delay to correct data on an enabled output. A \* shown without a number means the output is disabled by the input or it is enabled but the delay to correct data is determined by something else.

2. A "—" means the delay path does not exist.

3. Data in bold face is different from Table A; other data is the same.

TABLE IV E-E  
Guaranteed Combinational Delays  
 $T_C = -55^\circ\text{C}$  to  $+125^\circ\text{C}$ ,  $V_{CC} = 4.5\text{V}$  to  $5.5\text{V}$   
Two's Complement Divide, Correction  
( $I_{8765} = E_H$ ,  $I_{4321} = 0_H$ ,  $I_0 = 0$ )

| To Output<br>From Input             | Slice<br>Position | Y              | $C_{n+4}$ | $\overline{G}, \overline{P}$ | Z (s) | N   | OVR | DB | WRITE | QIO <sub>0</sub><br>QIO <sub>3</sub> | SIO <sub>0</sub> | SIO <sub>3</sub> | SIO <sub>0</sub><br>Parity |
|-------------------------------------|-------------------|----------------|-----------|------------------------------|-------|-----|-----|----|-------|--------------------------------------|------------------|------------------|----------------------------|
| A, B Address<br>(Arith. Mode)       | MSS               | 101            | 93        | —                            | —     | 102 | 118 | 52 | —     | —                                    | —                | 106              | —                          |
|                                     | IS, LSS           | 101            | 93        | 84                           | —     | —   | —   | 52 | —     | —                                    | —                | 106              | —                          |
| DA, DB Inputs                       | MSS               | 64             | 62        | —                            | —     | 66  | 94  | —  | —     | —                                    | —                | 71               | —                          |
|                                     | IS, LSS           | 64             | 62        | 51                           | —     | —   | —   | —  | —     | —                                    | —                | 71               | —                          |
| $\overline{EA}$                     | MSS               | 60             | 56        | —                            | —     | 60  | 87  | —  | —     | —                                    | —                | 64               | —                          |
|                                     | IS, LSS           | 60             | 56        | 43                           | —     | —   | —   | —  | —     | —                                    | —                | 64               | —                          |
| $C_n$                               | MSS               | 40             | 30        | —                            | —     | 40  | 59  | —  | —     | —                                    | —                | 46               | —                          |
|                                     | IS, LSS           | 40             | 30        | —                            | —     | —   | —   | —  | —     | —                                    | —                | 46               | —                          |
| $I_0$                               | MSS               | 98             | 96        | —                            | 42    | 96  | 127 | —  | —     | * 82                                 | *                | 105*             | —                          |
|                                     | IS                | 98             | 96        | 78                           | —     | —   | —   | —  | —     | *                                    | *                | 105*             | —                          |
|                                     | LSS               | 98             | 96        | 78                           | —     | —   | —   | —  | 53    | * 82                                 | *                | 105*             | —                          |
| $I_{4321}$                          | MSS               | 100            | 96        | —                            | 43    | 97  | 123 | —  | —     | * 82                                 | *                | 104*             | —                          |
|                                     | IS                | 100            | 96        | 84                           | —     | —   | —   | —  | —     | *                                    | *                | 104*             | —                          |
|                                     | LSS               | 100            | 96        | 84                           | —     | —   | —   | —  | 53    | * 82                                 | *                | 104*             | —                          |
| $I_{8765}$                          | MSS               | 85             | 78        | —                            | 44    | 78  | 95  | —  | —     | * 82                                 | *                | 89*              | —                          |
|                                     | IS                | 85             | 78        | 62                           | —     | —   | —   | —  | —     | *                                    | *                | 89*              | —                          |
|                                     | LSS               | 85             | 78        | 62                           | —     | —   | —   | —  | 50    | * 82                                 | *                | 89*              | —                          |
| Clock                               | MSS               | 89             | 90        | —                            | 58    | 89  | 116 | 39 | —     | 42                                   | —                | 96               | —                          |
|                                     | IS, LSS           | 89             | 90        | 74                           | —     | —   | —   | 39 | —     | 42                                   | —                | 96               | —                          |
| Z                                   | MSS               | Z is an output |           |                              |       |     |     |    |       |                                      |                  |                  |                            |
|                                     | IS, LSS           | 76             | 70        | 54                           | —     | —   | —   | —  | —     | —                                    | —                | 79               | —                          |
| $\overline{IEN}$                    | Any               | —              | —         | —                            | —     | —   | —   | —  | 24    | —                                    | —                | —                | —                          |
| SIO <sub>3</sub> , SIO <sub>0</sub> | Any               | 26             | —         | —                            | —     | —   | —   | —  | —     | —                                    | —                | —                | —                          |

$$F = R + S + C_n \text{ if } Z = 0$$

$$S - R - 1 + C_n \text{ if } Z = 1$$

$$Z = F_3 \oplus R_3 \text{ (MSS) from previous cycle}$$

Notes: 1. A "\*" means the output is enabled or disabled by the input. See Tables C for enable and disable times. A number shown with a \* is the delay to correct data on an enabled output. A \* shown without a number means the output is disabled by the input or it is enabled but the delay to correct data is determined by something else.

2. A "—" means the delay path does not exist.

3. Data in bold face is different from Table A; other data is the same.



# Am2903A

The Superslice®

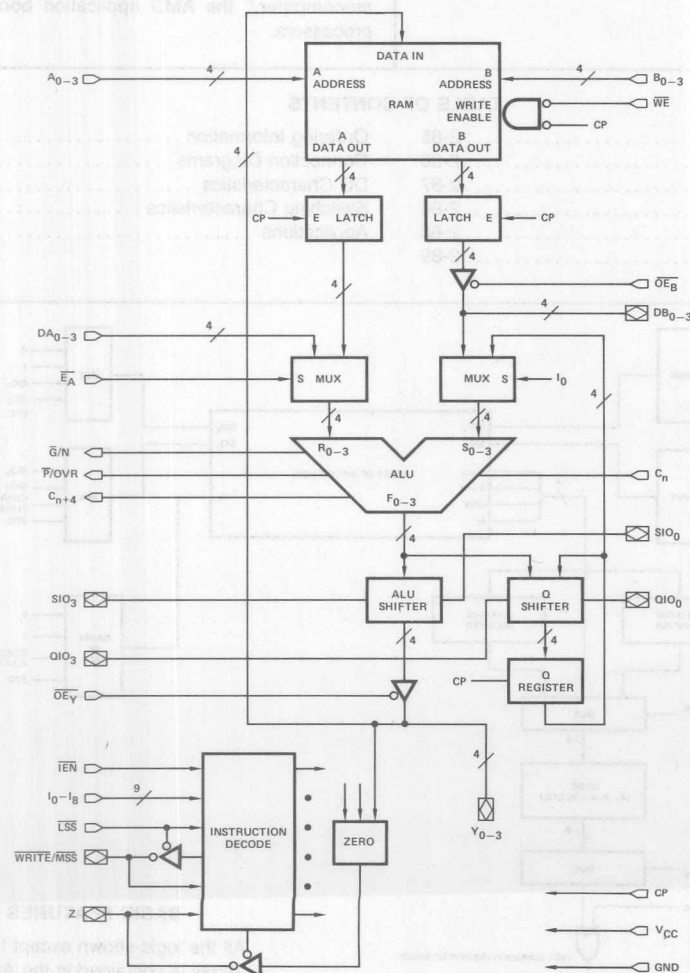
## ADVANCED INFORMATION

### DISTINCTIVE CHARACTERISTICS

- **Second generation of Am2903 Superslice®** —  
Improved design/process results in fastest version of the Am2903.
- **Plug-in replacement for Am2903** —  
The Am2903A is a pin-for-pin replacement for the original version of the Am2903. Only the switching speeds have changed.
- **At least 30% faster** —  
The design objective is for the Am2903A to be at least 30% faster than the original Am2903 on critical paths.

2

### BLOCK DIAGRAM



MPR-721

## DISTINCTIVE CHARACTERISTICS

- **Replaces most MSI used around any ALU** including the Am2901, Am2903 and MSI ALUs.
- **Generates Carry-In to the ALU**  
Carry signal is selectable from 7 different sources.
- **Contains shift linkage multiplexers**  
Connects to shift lines at the ends of an Am2901 or Am2903 array to implement single and double length arithmetic and logical shifts and rotates — 32 different modes in all.
- **Contains two edge-triggered status registers**  
Use for foreground/background registers in controllers or as microlevel and machine level status registers. Bit manipulating instructions are provided.
- **Condition Code Multiplexer on chip**  
Single cycle tests for any of 16 different conditions. Tests can be performed on either of the two status registers or directly on the ALU output.

## DESCRIPTION

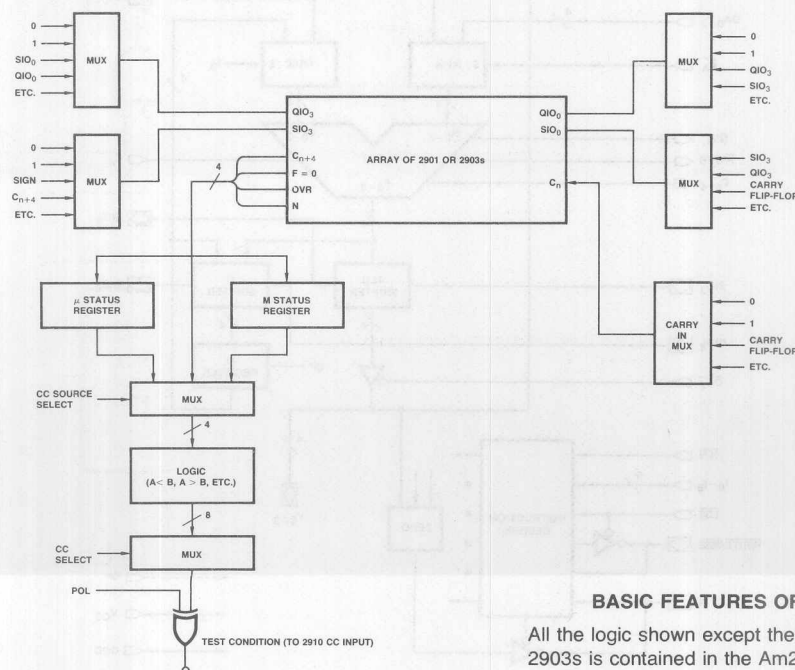
The Am2904 is designed to perform all the miscellaneous functions which are usually performed in MSI around an ALU. These include the generation of the carry-in signal to the ALU and carry lookahead unit; the interconnection of the data path, auxiliary register, and carry flip-flop during shift operations; and the storage and testing of ALU status flags. These tasks are accomplished in the Am2904 by three nearly independent blocks of logic. The carry-in is generated by a multiplexer. The shift linkages are established by four three-state multiplexers. There are two registers for storing the carry, overflow, zero, and negative status flags. The condition code multiplexer on the Am2904 can look at true or complement of any of the four status bits and certain combinations of status bits from either of the storage registers or directly from the ALU.

For additional applications refer to Chapter 4 of "Build A Microcomputer," the AMD application book on bipolar microprocessors.

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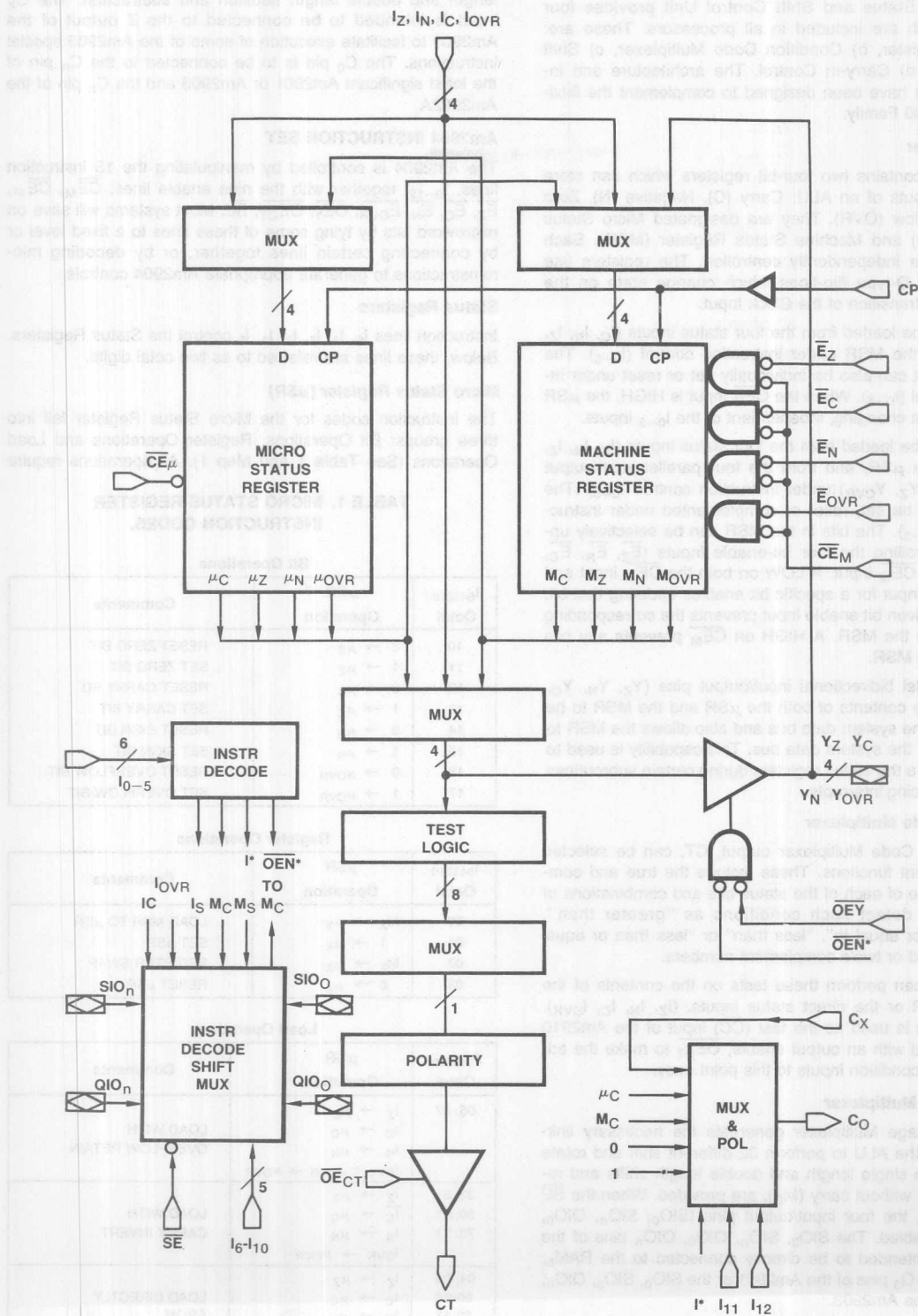
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## BASIC FEATURES OF Am2904

All the logic shown except the array of 2901s or 2903s is contained in the Am2904.

## BLOCK DIAGRAM



\*INTERNAL

MPR-060

## Am2904 ARCHITECTURE

The Am2904 Status and Shift Control Unit provides four functions which are included in all processors. These are: a) Status Register, b) Condition Code Multiplexer, c) Shift Linkages and d) Carry-in Control. The architecture and instruction codes have been designed to complement the flexibility of the 2900 Family.

### Status Register

The Am2904 contains two four-bit registers which can store the status outputs of an ALU: Carry (C), Negative (N), Zero (Z), and Overflow (OVR). They are designated Micro Status Register ( $\mu$ SR) and Machine Status Register (MSR). Each register can be independently controlled. The registers use edge-triggered D-type flip-flops which change state on the LOW to HIGH transition of the Clock Input.

The  $\mu$ SR can be loaded from the four status inputs ( $I_C$ ,  $I_N$ ,  $I_Z$ ,  $I_{OVR}$ ) or from the MSR under instruction control ( $I_{0-5}$ ). The bits in the  $\mu$ SR can also be individually set or reset under instruction control ( $I_{0-5}$ ). When the  $\overline{CE}_\mu$  input is HIGH, the  $\mu$ SR is inhibited from changing, independent of the  $I_{0-5}$  inputs.

The MSR can be loaded from the four status inputs ( $I_C$ ,  $I_N$ ,  $I_Z$ ,  $I_{OVR}$ ), from the  $\mu$ SR, and from the four parallel input/output pins ( $Y_C$ ,  $Y_N$ ,  $Y_Z$ ,  $Y_{OVR}$ ) under instruction control ( $I_{0-5}$ ). The MSR can also be set, reset or complemented under instruction control ( $I_{0-5}$ ). The bits in the MSR can be selectively updated by controlling the four bit-enable inputs ( $\overline{E}_Z$ ,  $\overline{E}_N$ ,  $\overline{E}_C$ ,  $\overline{E}_{OVR}$ ) and the  $\overline{CE}_M$  input. A LOW on both the  $\overline{CE}_M$  input and the bit enable input for a specific bit enables updating that bit. A HIGH on a given bit enable input prevents the corresponding bit changing in the MSR. A HIGH on  $\overline{CE}_M$  prevents any bits changing in the MSR.

The four parallel bidirectional input/output pins ( $Y_Z$ ,  $Y_N$ ,  $Y_C$ ,  $Y_{OVR}$ ) allow the contents of both the  $\mu$ SR and the MSR to be transferred to the system data bus and also allows the MSR to be loaded from the system data bus. This capability is used to save and restore the status registers during certain subroutines and when servicing interrupts.

### Condition Code Multiplexer

The Condition Code Multiplexer output, CT, can be selected from 16 different functions. These include the true and complemented state of each of the status bits and combinations of these bits to detect such conditions as "greater than", "greater than or equal to", "less than" or "less than or equal to" for unsigned or two's complement numbers.

The Am2904 can perform these tests on the contents of the  $\mu$ SR, the MSR or the direct status inputs, ( $I_Z$ ,  $I_N$ ,  $I_C$ ,  $I_{OVR}$ ). The CT output is used as the test ( $\overline{CC}$ ) input of the Am2910 and is provided with an output enable,  $\overline{OE}_{CT}$  to make the addition of other condition inputs to this point easy.

### Shift Linkage Multiplexer

The Shift Linkage Multiplexer generates the necessary linkages to allow the ALU to perform 32 different shift and rotate functions. Both single length and double length shifts and rotates, with and without carry ( $M_C$ ), are provided. When the  $\overline{SE}$  input is HIGH, the four input/output pins ( $SIO_0$ ,  $SIO_n$ ,  $QIO_0$ ,  $QIO_n$ ) are disabled. The  $SIO_0$ ,  $SIO_n$ ,  $QIO_0$ ,  $QIO_n$  pins of the Am2904 are intended to be directly connected to the  $RAM_0$ ,  $RAM_3$ ,  $Q_0$  and  $Q_3$  pins of the Am2901 or the  $SIO_0$ ,  $SIO_3$ ,  $QIO_0$ ,  $QIO_3$  pins of the Am2903.

### Carry-In Control Multiplexer

The Carry-In Control Multiplexer generates the  $C_0$  output which can be selected from 7 functions (0, 1,  $C_X$ ,  $\mu_C$ ,  $M_C$ ,  $\mu_C$ ,  $\overline{M_C}$ ).

These functions allow easy implementation of both single length and double length addition and subtraction. The  $C_X$  input is intended to be connected to the Z output of the Am2903 to facilitate execution of some of the Am2903 special instructions. The  $C_0$  pin is to be connected to the  $C_n$  pin of the least significant Am2901 or Am2903 and the  $C_n$  pin of the Am2902A.

## Am2904 INSTRUCTION SET

The Am2904 is controlled by manipulating the 13 instruction lines,  $I_{0-12}$ , together with the nine enable lines,  $\overline{CE}_M$ ,  $\overline{CE}_\mu$ ,  $\overline{E}_Z$ ,  $\overline{E}_C$ ,  $\overline{E}_N$ ,  $\overline{E}_{OVR}$ ,  $\overline{OE}_Y$ ,  $\overline{OE}_{CT}$ ,  $\overline{SE}$ . Most systems will save on microword bits by tying some of these lines to a fixed level or by connecting certain lines together, or by decoding microinstructions to generate appropriate Am2904 controls.

### Status Registers

Instruction lines  $I_5$ ,  $I_4$ ,  $I_3$ ,  $I_2$ ,  $I_1$ ,  $I_0$  control the Status Registers. Below, these lines are referred to as two octal digits.

### Micro Status Register ( $\mu$ SR)

The instruction codes for the Micro Status Register fall into three groups: Bit Operations, Register Operations and Load Operations (See Table 1 and Map 1). All operations require

TABLE 1. MICRO STATUS REGISTER INSTRUCTION CODES.

| Bit Operations                             |  |  |
|--|--|--|
| $I_{543210}$<br>Octal                      | $\mu$ SR<br>Operation  | Comments   |
| 10   | 0 $\rightarrow \mu_Z$  | RESET ZERO BIT   |
| 11   | 1 $\rightarrow \mu_Z$  | SET ZERO BIT   |
| 12   | 0 $\rightarrow \mu_C$  | RESET CARRY BIT  |
| 13   | 1 $\rightarrow \mu_C$  | SET CARRY BIT  |
| 14   | 0 $\rightarrow \mu_N$  | RESET SIGN BIT   |
| 15   | 1 $\rightarrow \mu_N$  | SET SIGN BIT   |
| 16   | 0 $\rightarrow \mu_{OVR}$  | RESET OVERFLOW BIT   |
| 17   | 1 $\rightarrow \mu_{OVR}$  | SET OVERFLOW BIT   |
| Register Operations                        |  |  |
| $I_{543210}$<br>Octal                      | $\mu$ SR<br>Operation  | Comments   |
| 00   | $M_X \rightarrow \mu_X$  | LOAD MSR TO $\mu$ SR                                       |
| 01   | 1 $\rightarrow \mu_X$  | SET $\mu$ SR   |
| 02   | $M_X \rightarrow \mu_X$  | REGISTER SWAP  |
| 03   | 0 $\rightarrow \mu_X$  | RESET $\mu$ SR   |
| Load Operations                            |  |  |
| $I_{543210}$<br>Octal                      | $\mu$ SR<br>Operation  | Comments   |
| 06, 07                                     | $I_Z \rightarrow \mu_Z$<br>$I_C \rightarrow \mu_C$<br>$I_N \rightarrow \mu_N$<br>$I_{OVR} + \mu_{OVR} \rightarrow \mu_{OVR}$ | LOAD WITH<br>OVERFLOW RETAIN                               |
| 30, 31<br>50, 51<br>70, 71                 | $I_Z \rightarrow \mu_Z$<br>$I_C \rightarrow \mu_C$<br>$I_N \rightarrow \mu_N$<br>$I_{OVR} \rightarrow \mu_{OVR}$             | LOAD WITH<br>CARRY INVERT                                  |
| 04, 05<br>20-27<br>32-47<br>52-67<br>72-77 | $I_Z \rightarrow \mu_Z$<br>$I_C \rightarrow \mu_C$<br>$I_N \rightarrow \mu_N$<br>$I_{OVR} \rightarrow \mu_{OVR}$             | LOAD DIRECTLY<br>FROM<br>$I_Z$ , $I_C$ , $I_N$ , $I_{OVR}$ |

Note: The above tables assume  $\overline{CE}_\mu$  is LOW.



MAP 1. MICRO STATUS REGISTER INSTRUCTION CODES.

| I <sub>210</sub> | 000                    | 001     | 010      | 011       | 100      | 101    | 110        | 111                       |
|------------------|------------------------|---------|----------|-----------|----------|--------|------------|---------------------------|
| 000              | LOAD MSR TO #SR        | SET #SR | REG SWAP | RESET #SR |          |        |            | LOAD WITH OVERFLOW RETAIN |
| 001              | RESET #Z               | SET #Z  | RESET #C | SET #C    | RESET #N | SET #N | RESET #OVR | SET #OVR                  |
| 010              |                        |         |          |           |          |        |            |                           |
| 011              | LOAD WITH CARRY INVERT |         |          |           |          |        |            |                           |
| 100              |                        |         |          |           |          |        |            |                           |
| 101              | LOAD WITH CARRY INVERT |         |          |           |          |        |            |                           |
| 110              |                        |         |          |           |          |        |            |                           |
| 111              | LOAD WITH CARRY INVERT |         |          |           |          |        |            |                           |

Notes: 1. All unmarked locations are a load direct from I<sub>Z</sub>, I<sub>C</sub>, I<sub>N</sub>, I<sub>OVR</sub>.

that  $\overline{CE}_\mu$  be LOW to operate.

Instruction Codes 10<sub>8</sub> to 17<sub>8</sub> are BIT operations. These operations set or reset the individual bits in the  $\mu$ SR.

Instruction Codes 00<sub>8</sub> to 03<sub>8</sub> are REGISTER operations. These operations affect all bits in the  $\mu$ SR.

00<sub>8</sub> This instruction loads the  $\mu$ SR with the contents of the MSR while loading the MSR from the Y inputs and is further explained under "INTERRUPTS".

01<sub>8</sub> This instruction SETS all  $\mu$ SR bits.

02<sub>8</sub> This instruction SWAPS the contents of the  $\mu$ SR and the MSR. It will also COPY one register to the other if the register to be copied is not enabled.

03<sub>8</sub> This instruction RESETS all  $\mu$ SR bits.

All instruction codes except those mentioned in the above two sections cause a LOAD operation from the I<sub>Z</sub>, I<sub>C</sub>, I<sub>N</sub>, I<sub>OVR</sub> inputs.

06<sub>8</sub>, 07<sub>8</sub> When a series of arithmetic operations are being executed sometimes it is not necessary to test for an overflow condition after *each* operation, but rather it is sufficient simply to know that an overflow occurred during any one of the operations. Use of these instructions captures the overflow condition by loading the  $\mu$ SR overflow bit with the LOGICAL OR of its present state and I<sub>OVR</sub>. Thus, once an overflow occurs,  $\mu$ OVR will remain set throughout the remaining operations.

30<sub>8</sub>, 31<sub>8</sub>, 50<sub>8</sub>, 51<sub>8</sub>, 70<sub>8</sub>, 71<sub>8</sub> These instructions cause a load from the I inputs, but invert the carry bit. The reason for this is explained more fully under the "BORROW SAVE" section.

All others The remaining instructions load the  $\mu$ SR directly from the I<sub>Z</sub>, I<sub>C</sub>, I<sub>N</sub>, I<sub>OVR</sub> inputs.

#### Machine Status Register (MSR)

The instruction codes for the MSR fall into two groups; REGISTER Operations and LOAD Operations. All operations require that  $\overline{CE}_M$  be LOW to operate (See Table 2 and Map 2).

BIT operations are accomplished by the use of Register or Load Operations with the  $\overline{E}_Z$ ,  $\overline{E}_C$ ,  $\overline{E}_N$ ,  $\overline{E}_{OVR}$  inputs selectively set LOW.

Instruction codes 00<sub>8</sub>-03<sub>8</sub> and 05<sub>8</sub> are REGISTER operations. They affect only those bits enabled by  $\overline{E}_Z$ ,  $\overline{E}_C$ ,  $\overline{E}_N$ ,  $\overline{E}_{OVR}$ .

00<sub>8</sub> This instruction loads the MSR from the Y inputs while transferring the present contents to the  $\mu$ SR. The use of this instruction is further explained under "INTERRUPTS".

01<sub>8</sub> This instruction SETS all enabled MSR bits.

02<sub>8</sub> This instruction SWAPS the contents of the  $\mu$ SR and the MSR. It will also COPY one register to the other if the register to be copied is not enabled.

03<sub>8</sub> This instruction RESETS all enabled MSR bits.

05<sub>8</sub> This instruction COMPLEMENTS all enabled MSR bits.

All instruction codes except those mentioned in the above section cause a LOAD operation from the I<sub>Z</sub>, I<sub>C</sub>, I<sub>N</sub>, I<sub>OVR</sub> inputs.

04<sub>8</sub> The Am2904 Shift Linkage Multiplexer allows for shifts and rotates through the MSR CARRY bit. Some machines require a shift or rotate through the OVERFLOW bit. By using this code, which swaps the contents of the MSR CARRY bit (M<sub>C</sub>) and OVERFLOW bit (M<sub>OVR</sub>), the shift or rotate can be made to appear to take place through the OVERFLOW bit. The procedure is to swap the bits, shift or rotate (any number or positions) then swap the bits again.

TABLE 2. MACHINE STATUS REGISTER INSTRUCTION CODES.

#### Register Operations

| I <sub>543210</sub><br>Octal | MSR<br>Operation                  | Comments  |
|------------------------------|-----------------------------------|---|
| 00                           | Y <sub>X</sub> → M <sub>X</sub>   | LOAD Y <sub>Z</sub> , Y <sub>C</sub> , Y <sub>N</sub> , Y <sub>OVR</sub> TO MSR |
| 01                           | 1 → M <sub>X</sub>                | SET MSR   |
| 02                           | μ <sub>X</sub> → M <sub>X</sub>   | REGISTER SWAP   |
| 03                           | 0 → M <sub>X</sub>                | RESET MSR   |
| 05                           | $\overline{M}_X$ → M <sub>X</sub> | INVERT MSR  |

#### Load Operations

| I <sub>543210</sub><br>Octal                                 | MSR<br>Operation   | Comments  |
|--|--|---|
| 04   | I <sub>Z</sub> → M <sub>Z</sub><br>M <sub>OVR</sub> → M <sub>C</sub><br>I <sub>N</sub> → M <sub>N</sub><br>M <sub>C</sub> → M <sub>OVR</sub>   | LOAD FOR SHIFT THROUGH OVERFLOW OPERATION   |
| 10, 11<br>30, 31<br>50, 51<br>70, 71                         | I <sub>Z</sub> → M <sub>Z</sub><br>$\overline{I}_C$ → M <sub>C</sub><br>I <sub>N</sub> → M <sub>N</sub><br>I <sub>OVR</sub> → M <sub>OVR</sub> | LOAD WITH CARRY INVERT  |
| 06, 07<br>12-17<br>20-27<br>32-37<br>40-47<br>52-67<br>72-77 | I <sub>Z</sub> → M <sub>Z</sub><br>I <sub>C</sub> → M <sub>C</sub><br>I <sub>N</sub> → M <sub>N</sub><br>I <sub>OVR</sub> → M <sub>OVR</sub>   | LOAD DIRECTLY FROM I <sub>Z</sub> , I <sub>C</sub><br>I <sub>N</sub> , I <sub>OVR</sub> |

Notes: 1. The above tables assume  $\overline{CE}_M$ ,  $\overline{E}_Z$ ,  $\overline{E}_C$ ,  $\overline{E}_N$ ,  $\overline{E}_{OVR}$  are LOW.

2. A shift-through-carry instruction loads M<sub>C</sub> irrespective of I<sub>5</sub>-I<sub>0</sub>.

| I <sub>210</sub> | 000                    | 001     | 010      | 011       | 100                      | 101        | 110 | 111 |
|------------------|------------------------|---------|----------|-----------|--------------------------|------------|-----|-----|
| 000              | LOAD MSR FROM Y        | SET MSR | REG SWAP | RESET MSR | SWAP M <sub>C</sub> MOVR | INVERT MSR |     |     |
| 001              | LOAD WITH CARRY INVERT |         |          |           |                          |            |     |     |
| 010              |                        |         |          |           |                          |            |     |     |
| 011              | LOAD WITH CARRY INVERT |         |          |           |                          |            |     |     |
| 100              |                        |         |          |           |                          |            |     |     |
| 101              | LOAD WITH CARRY INVERT |         |          |           |                          |            |     |     |
| 110              |                        |         |          |           |                          |            |     |     |
| 111              | LOAD WITH CARRY INVERT |         |          |           |                          |            |     |     |

Note 1. All unmarked locations are a load direct from I<sub>Z</sub>, I<sub>C</sub>, I<sub>NOVR</sub>, I<sub>N</sub>.

06<sub>8</sub>, 07<sub>8</sub>  
12<sub>8</sub>-27<sub>8</sub>  
32<sub>8</sub>-47<sub>8</sub>  
52<sub>8</sub>-67<sub>8</sub>  
72<sub>8</sub>-77<sub>8</sub>

These instructions load the MSR directly from the I<sub>Z</sub>, I<sub>C</sub>, I<sub>N</sub>, I<sub>NOVR</sub> inputs.

50<sub>8</sub>, 51<sub>8</sub>  
70<sub>8</sub>, 71<sub>8</sub>

explained more fully under the "BORROW SAVE" section

### Condition Code Multiplexer

The four instruction lines I<sub>3</sub>, I<sub>2</sub>, I<sub>1</sub>, I<sub>0</sub> will select one of 16 possible operations to be carried out on the input bits, the result being routed to the Conditional Test Output (CT). Eight of the operations supply an individual status bit or its complement to the CT output. Another four do more complex operations while the remaining four are the complemented results of these (See Table 4).

TABLE 3. Y OUTPUT INSTRUCTION CODES.

| $\overline{OE}_Y$ | I <sub>5</sub> | I <sub>4</sub> | Y Output                | Comment                      |
|-------------------|----------------|----------------|-------------------------|------------------------------|
| 1                 | X              | X              | Z                       | Output Off<br>High Impedance |
| 0                 | 0              | X              | $\mu_i \rightarrow Y_i$ | See Note 1                   |
| 0                 | 1              | 0              | $M_i \rightarrow Y_i$   |                              |
| 0                 | 1              | 1              | $I_i \rightarrow Y_i$   |                              |

Notes: 1. For the conditions:

I<sub>5</sub>, I<sub>4</sub>, I<sub>3</sub>, I<sub>2</sub>, I<sub>1</sub>, I<sub>0</sub> are LOW, Y is an input.

$\overline{OE}_Y$  is "Don't Care" for this condition.

2. X is "Don't Care" condition.

TABLE 4. CONDITION CODE OUTPUT (CT) INSTRUCTION CODES.

| I <sub>3</sub> - 0<br>HEX | I <sub>3</sub> | I <sub>2</sub> | I <sub>1</sub> | I <sub>0</sub> | I <sub>5</sub> = I <sub>4</sub> = 0         | I <sub>5</sub> = 0, I <sub>4</sub> = 1      | I <sub>5</sub> = 1, I <sub>4</sub> = 0 | I <sub>5</sub> = I <sub>4</sub> = 1   |
|---------------------------|----------------|----------------|----------------|----------------|---|---|--|---------------------------------------|
| 0                         | 0              | 0              | 0              | 0              | $(\mu_N \oplus \mu_{OVR}) + \mu_Z$          | $(\mu_N \oplus \mu_{OVR}) + \mu_Z$          | $(M_N \oplus M_{OVR}) + M_Z$           | $(I_N \oplus I_{OVR}) + I_Z$          |
| 1                         | 0              | 0              | 0              | 1              | $(\mu_N \odot \mu_{OVR}) \cdot \bar{\mu}_Z$ | $(\mu_N \odot \mu_{OVR}) \cdot \bar{\mu}_Z$ | $(M_N \odot M_{OVR}) \cdot \bar{M}_Z$  | $(I_N \odot I_{OVR}) \cdot \bar{I}_Z$ |
| 2                         | 0              | 0              | 1              | 0              | $\mu_N \oplus \mu_{OVR}$                    | $\mu_N \oplus \mu_{OVR}$                    | $M_N \oplus M_{OVR}$                   | $I_N \oplus I_{OVR}$                  |
| 3                         | 0              | 0              | 1              | 1              | $\mu_N \odot \mu_{OVR}$                     | $\mu_N \odot \mu_{OVR}$                     | $M_N \odot M_{OVR}$                    | $I_N \odot I_{OVR}$                   |
| 4                         | 0              | 1              | 0              | 0              | $\mu_Z$                                     | $\mu_Z$                                     | $M_Z$                                  | $I_Z$                                 |
| 5                         | 0              | 1              | 0              | 1              | $\bar{\mu}_Z$                               | $\bar{\mu}_Z$                               | $\bar{M}_Z$                            | $\bar{I}_Z$                           |
| 6                         | 0              | 1              | 1              | 0              | $\mu_{OVR}$                                 | $\mu_{OVR}$                                 | $M_{OVR}$                              | $I_{OVR}$                             |
| 7                         | 0              | 1              | 1              | 1              | $\bar{\mu}_{OVR}$                           | $\bar{\mu}_{OVR}$                           | $\bar{M}_{OVR}$                        | $\bar{I}_{OVR}$                       |
| 8                         | 1              | 0              | 0              | 0              | $\mu_C + \mu_Z$                             | $\mu_C + \mu_Z$                             | $\bar{M}_C + M_Z$                      | $\bar{I}_C + I_Z$                     |
| 9                         | 1              | 0              | 0              | 1              | $\bar{\mu}_C \cdot \bar{\mu}_Z$             | $\bar{\mu}_C \cdot \bar{\mu}_Z$             | $\bar{M}_C \cdot \bar{M}_Z$            | $\bar{I}_C \cdot \bar{I}_Z$           |
| A                         | 1              | 0              | 1              | 0              | $\mu_C$                                     | $\mu_C$                                     | $M_C$                                  | $I_C$                                 |
| B                         | 1              | 0              | 1              | 1              | $\bar{\mu}_C$                               | $\bar{\mu}_C$                               | $\bar{M}_C$                            | $\bar{I}_C$                           |
| C                         | 1              | 1              | 0              | 0              | $\bar{\mu}_C + \mu_Z$                       | $\bar{\mu}_C + \mu_Z$                       | $\bar{M}_C + M_Z$                      | $\bar{I}_C + I_Z$                     |
| D                         | 1              | 1              | 0              | 1              | $\mu_C \cdot \bar{\mu}_Z$                   | $\mu_C \cdot \bar{\mu}_Z$                   | $M_C \cdot \bar{M}_Z$                  | $I_C \cdot \bar{I}_Z$                 |
| E                         | 1              | 1              | 1              | 0              | $I_N \oplus M_N$                            | $\mu_N$                                     | $M_N$                                  | $I_N$                                 |
| F                         | 1              | 1              | 1              | 1              | $I_N \odot M_N$                             | $\bar{\mu}_N$                               | $\bar{M}_N$                            | $\bar{I}_N$                           |

Notes: 1.  $\oplus$  Represents EXCLUSIVE-OR

$\odot$  Represents EXCLUSIVE-NOR or coincidence.

TABLE 5. CRITERIA FOR COMPARING TWO NUMBERS FOLLOWING "A MINUS B" OPERATION.

| Relation | Status                | For Unsigned Numbers |        | For 2's Complement Numbers        |                  |        |
|----------|-----------------------|----------------------|--------|-----------------------------------|------------------|--------|
|          |                       | I <sub>3-0</sub>     |        | Status                            | I <sub>3-0</sub> |        |
|          |                       | CT = H               | CT = L |                                   | CT = H           | CT = L |
| A = B    | Z = 1                 | 4                    | 5      | Z = 1                             | 4                | 5      |
| A ≠ B    | Z = 0                 | 5                    | 4      | Z = 0                             | 5                | 4      |
| A ≥ B    | C = 1                 | A                    | B      | $N \odot OVR = 1$                 | 3                | 2      |
| A < B    | C = 0                 | B                    | A      | $N \oplus OVR = 1$                | 2                | 3      |
| A > B    | $C \cdot \bar{Z} = 1$ | D                    | C      | $(N \odot OVR) \cdot \bar{Z} = 1$ | 1                | 0      |
| A ≤ B    | $\bar{C} + Z = 1$     | C                    | D      | $(N \oplus OVR) + Z = 1$          | 0                | 1      |

$\oplus$  = Exclusive OR

H = HIGH

$\odot$  = Exclusive NOR

L = LOW

Note: For Am2910, the CC input is active LOW, so use I<sub>3-0</sub> code to produce CT = L for the desired test.

The more complex operations are intended to follow the calculation A-B to give an indication of which is the larger (A, B unsigned) or more positive (A, B in 2's complement form). See Table 5.

The two instruction lines  $I_4$ ,  $I_5$  select whether the  $\mu$ SR, the MSR or the direct inputs  $I_2$ ,  $I_C$ ,  $I_N$ ,  $I_{OVR}$  are used as the inputs to the Y output buffer and the CT output (see Tables 3 and 4).

Instruction codes  $16_8$  and  $17_8$  form the EXCLUSIVE - OR and the EXCLUSIVE - NOR functions of  $M_N$  and  $I_N$ . The use of these instructions is explained under "NORMALIZING"

#### Shift Linkage Multiplexer

The five instruction lines  $I_{10}$ ,  $I_9$ ,  $I_8$ ,  $I_7$ ,  $I_6$  control the SHIFT LINKAGE multiplexer. All instructions set up the linkages for both the ALU shifter (RAM shifter on the Am2901A) and the Q register.

UP and DOWN shifts are decided by  $I_{10}$  which should be connected to  $I_8$  of the Am2903's instruction lines or  $I_7$  of the Am2901's instruction lines. A wide range of input and output connections are provided, allowing for single or double length shifting or rotating with or without the use of the MSR CARRY or SIGN bits (See Table 7).

In the following discussion of some of the shifts the instruction codes are given as two octal digits AB; A represents  $I_{10}$ ,  $I_9$ , B represents  $I_8$ ,  $I_7$ ,  $I_6$ .

When adding and down shifting on the same microcycle, (i.e. when doing multiplication or averaging) the shifter input must be the present CARRY,  $I_C$ , rather than the carry resulting from the last cycle ( $M_C$ ). Instruction Code  $13_8$  accomplishes this for unsigned arithmetic. For 2's complement arithmetic, the required shifter input is:  $I_N \oplus I_{OVR}$ . This is provided by Instruction Code  $16_8$ .

Instruction Codes  $14_8$ ,  $15_8$ ,  $17_8$  provide the RIGHT ROTATE THROUGH CARRY, ROTATE BRANCH CARRY and ROTATE WITHOUT CARRY functions respectively.

Instruction Codes  $34_8$ ,  $35_8$ ,  $37_8$  provide the LEFT ROTATE THROUGH CARRY, ROTATE BRANCH CARRY and ROTATE WITHOUT CARRY functions respectively.

The shift outputs are in the high impedance state unless  $\overline{SE}$  is LOW.

Loading of the  $M_C$  bit by a shift operation overrides any loading or holding of the  $M_C$  bit by MSR Instructions ( $I_{0-5}$ ,  $\overline{CE}_M$  and  $\overline{EC}$ ).

#### "CARRY-IN" Control Multiplexer

The two instruction lines  $I_{12}$ ,  $I_{11}$  control the source of the CARRY output ( $C_0$ ).

When  $I_{12} = 0$   $C_0 = I_{11}$

When  $I_{12} = 1$  and  $I_{11} = 0$ , the external carry input  $C_X$  is presented to the carry output.

When  $I_{12} = I_{11} = 1$  the carry output is selected from  $\mu_C$ ,  $\overline{\mu_C}$ ,  $M_C$  or  $\overline{M_C}$  as defined by  $I_5$ ,  $I_3$ ,  $I_2$ ,  $I_1$  (See Table 6).

#### APPLICATIONS INFORMATION

##### Borrow - Save

One of the capabilities of the Am2900 Family is the complete emulation of other processing machines. One requirement of an emulator is that, when a calculation is being performed, not only must the answer obtained from the Am2900 chips be the same as that from the machine being emulated, but after each machine level instruction, the status bits must be identical.

TABLE 6. CARRY-IN CONTROL  
MULTIPLEXER INSTRUCTION CODES.

| $I_{12}$ | $I_{11}$ | $I_5$ | $I_3$ | $I_2$ | $I_1$ | $C_0$              |
|----------|----------|-------|-------|-------|-------|--------------------|
| 0        | 0        | X     | X     | X     | X     | 0                  |
| 0        | 1        | X     | X     | X     | X     | 1                  |
| 1        | 0        | X     | X     | X     | X     | $C_X$              |
| 1        | 1        | 0     | 0     | X     | X     | $\mu_C$            |
| 1        | 1        | 0     | X     | 1     | X     | $\mu_C$            |
| 1        | 1        | 0     | X     | X     | 1     | $\mu_C$            |
| 1        | 1        | 0     | 1     | 0     | 0     | $\overline{\mu_C}$ |
| 1        | 1        | 1     | 0     | X     | X     | $M_C$              |
| 1        | 1        | 1     | X     | 1     | X     | $M_C$              |
| 1        | 1        | 1     | X     | X     | 1     | $M_C$              |
| 1        | 1        | 1     | 1     | 0     | 0     | $\overline{M_C}$   |

There are alternative methods for subtracting in a digital machine and the state of the CARRY after the calculation depends on the method. For instance, the subtraction of 0100 from 1010 by the 2's complement add method generates a result of 0110 with a CARRY. Direct subtraction however, yields an answer of 0110 with no BORROW.

Many machines store the state of the CARRY for subtract operations, and this is the recommended method for maximum effective use of the Am2904, but, to allow those machines which store the BORROW to be efficiently emulated, the Am2904 has allocated special instructions. Using these codes causes the CARRY bit to be inverted before storage in the status registers and also re-inverts these status bits before using them as carry inputs. These codes are  $10_8$ ,  $11_8$ ,  $30_8$ ,  $31_8$ ,  $50_8$ ,  $51_8$ ,  $70_8$ ,  $71_8$  ( $I_5=0$ ).

Notice that when these codes are used to load the inverted CARRY to either of the status registers, the CT output selected by the Condition Code Multiplexer assumes the CARRY is inverted and still defines whether  $A > B$  or  $A \leq B$  (See Table 4).

Similarly, when doing a compare on a machine which saves the borrow, testing for  $A > B$ ,  $A \leq B$  forces the complement of the CARRY to be stored in the status registers (See Tables 1 and 2).

#### Normalizing

Normalizing is the process of stripping off all leading sign bits until the two most significant bits are complementary. The Am2904 facilitates both single and double length normalization in the Am2901 and the Am2903. When using the NORMALIZE special instructions with the Am2903, the EXCLUSIVE - OR of the most significant two bits is generated at the  $C_{n+4}$  pin of the most significant Am2903. The EXCLUSIVE - OR of the two bits next to the most significant bit is also generated at the OVR pin. The procedure for normalizing then is to loop on the normalize instruction with a branch condition on the  $C_{n+4}$  state or the OVR state, depending on the architecture employed. The  $C_{n+4}$  or OVR output is routed to the Am2901 CC input through the Am2904 Condition Code multiplexer. As the contents of the status registers always refers to the last cycle, not the present one, the last operation in Normalizing is to downshift, bringing the sign bit ( $M_N$ ) back into the most significant bit position. This is achieved using the shift operations  $05_8$  ( $I_{10-6}$ ) for double length normalizing,

TABLE 7. SHIFT LINKAGE MULTIPLEXER INSTRUCTION CODES.

| I <sub>10</sub> | I <sub>9</sub> | I <sub>8</sub> | I <sub>7</sub> | I <sub>6</sub> | M <sub>C</sub> | RAM | Q | SIO <sub>0</sub> | SIO <sub>n</sub>                  | QIO <sub>0</sub> | QIO <sub>n</sub> | Loaded into M <sub>C</sub> |
|-----------------|----------------|----------------|----------------|----------------|----------------|-----|---|------------------|-----------------------------------|------------------|------------------|----------------------------|
| 0               | 0              | 0              | 0              | 0              |                |     |   | Z                | 0                                 | Z                | 0                |                            |
| 0               | 0              | 0              | 0              | 1              |                |     |   | Z                | 1                                 | Z                | 1                |                            |
| 0               | 0              | 0              | 1              | 0              |                |     |   | Z                | 0                                 | Z                | M <sub>N</sub>   | SIO <sub>0</sub>           |
| 0               | 0              | 0              | 1              | 1              |                |     |   | Z                | 1                                 | Z                | SIO <sub>0</sub> |                            |
| 0               | 0              | 1              | 0              | 0              |                |     |   | Z                | M <sub>C</sub>                    | Z                | SIO <sub>0</sub> |                            |
| 0               | 0              | 1              | 0              | 1              |                |     |   | Z                | M <sub>N</sub>                    | Z                | SIO <sub>0</sub> |                            |
| 0               | 0              | 1              | 1              | 0              |                |     |   | Z                | 0                                 | Z                | SIO <sub>0</sub> |                            |
| 0               | 0              | 1              | 1              | 1              |                |     |   | Z                | 0                                 | Z                | SIO <sub>0</sub> | QIO <sub>0</sub>           |
| 0               | 1              | 0              | 0              | 0              |                |     |   | Z                | SIO <sub>0</sub>                  | Z                | QIO <sub>0</sub> | SIO <sub>0</sub>           |
| 0               | 1              | 0              | 0              | 1              |                |     |   | Z                | M <sub>C</sub>                    | Z                | QIO <sub>0</sub> | SIO <sub>0</sub>           |
| 0               | 1              | 0              | 1              | 0              |                |     |   | Z                | SIO <sub>0</sub>                  | Z                | QIO <sub>0</sub> |                            |
| 0               | 1              | 0              | 1              | 1              |                |     |   | Z                | I <sub>C</sub>                    | Z                | SIO <sub>0</sub> |                            |
| 0               | 1              | 1              | 0              | 0              |                |     |   | Z                | M <sub>C</sub>                    | Z                | SIO <sub>0</sub> | QIO <sub>0</sub>           |
| 0               | 1              | 1              | 0              | 1              |                |     |   | Z                | QIO <sub>0</sub>                  | Z                | SIO <sub>0</sub> | QIO <sub>0</sub>           |
| 0               | 1              | 1              | 1              | 0              |                |     |   | Z                | I <sub>N</sub> ⊕ I <sub>0VR</sub> | Z                | SIO <sub>0</sub> |                            |
| 0               | 1              | 1              | 1              | 1              |                |     |   | Z                | QIO <sub>0</sub>                  | Z                | SIO <sub>0</sub> |                            |
| 1               | 0              | 0              | 0              | 0              |                |     |   | 0                | Z                                 | 0                | Z                | SIO <sub>n</sub>           |
| 1               | 0              | 0              | 0              | 1              |                |     |   | 1                | Z                                 | 1                | Z                | SIO <sub>n</sub>           |
| 1               | 0              | 0              | 1              | 0              |                |     |   | 0                | Z                                 | 0                | Z                |                            |
| 1               | 0              | 0              | 1              | 1              |                |     |   | 1                | Z                                 | 1                | Z                |                            |
| 1               | 0              | 1              | 0              | 0              |                |     |   | QIO <sub>n</sub> | Z                                 | 0                | Z                | SIO <sub>n</sub>           |
| 1               | 0              | 1              | 0              | 1              |                |     |   | QIO <sub>n</sub> | Z                                 | 1                | Z                | SIO <sub>n</sub>           |
| 1               | 0              | 1              | 1              | 0              |                |     |   | QIO <sub>n</sub> | Z                                 | 0                | Z                |                            |
| 1               | 0              | 1              | 1              | 1              |                |     |   | QIO <sub>n</sub> | Z                                 | 1                | Z                |                            |
| 1               | 1              | 0              | 0              | 0              |                |     |   | SIO <sub>n</sub> | Z                                 | QIO <sub>n</sub> | Z                | SIO <sub>n</sub>           |
| 1               | 1              | 0              | 0              | 1              |                |     |   | M <sub>C</sub>   | Z                                 | QIO <sub>n</sub> | Z                | SIO <sub>n</sub>           |
| 1               | 1              | 0              | 1              | 0              |                |     |   | SIO <sub>n</sub> | Z                                 | QIO <sub>n</sub> | Z                |                            |
| 1               | 1              | 0              | 1              | 1              |                |     |   | M <sub>C</sub>   | Z                                 | 0                | Z                |                            |
| 1               | 1              | 1              | 0              | 0              |                |     |   | QIO <sub>n</sub> | Z                                 | M <sub>C</sub>   | Z                | SIO <sub>n</sub>           |
| 1               | 1              | 1              | 0              | 1              |                |     |   | QIO <sub>n</sub> | Z                                 | SIO <sub>n</sub> | Z                | SIO <sub>n</sub>           |
| 1               | 1              | 1              | 1              | 0              |                |     |   | QIO <sub>n</sub> | Z                                 | M <sub>C</sub>   | Z                |                            |
| 1               | 1              | 1              | 1              | 1              |                |     |   | QIO <sub>n</sub> | Z                                 | SIO <sub>n</sub> | Z                |                            |

Notes: 1. Z = High impedance (outputs off) state.

2. Outputs enabled and M<sub>C</sub> loaded only if SE is LOW.3. Loading of M<sub>C</sub> from I<sub>10-6</sub> overrides control from I<sub>5-0</sub>,  $\overline{CE}_M$ ,  $\overline{E}_C$ .



and  $02_8$  for single length normalizing. For more details regarding normalizing with the Am2903 see the Am2903 data sheet.

The Am2901 does not have the EXCLUSIVE - OR gates to help with normalizing, so the Am2904 includes in the Condition Code multiplexer the EXCLUSIVE - OR and EXCLUSIVE - NOR functions of  $M_N$  (the sign bit resulting from the last operation) and  $I_N$  (the sign bit resulting from the present operation).

### Interrupts

Some machines allow interrupts only at the machine instruction level while others allow them at the microinstruction level. The Am2904 is designed to handle both cases.

When the machine is interrupted, it is necessary to store the contents of either the MSR (machine instruction level interrupts) or both the status registers (micro instruction level inter-

rupts) into an external store. This transfer is intended to take place over the Y input/output pins (See Table 3).

After the interrupt has been serviced the registers must be restored to their pre-interrupt state. This is accomplished by two operations of instruction  $00_8$  ( $I_5=0$ ) which loads the MSR from the Y inputs while loading the  $\mu$ SR from the MSR. Thus, the pre-interrupt contents of the  $\mu$ SR are first loaded to the MSR (first instruction  $00_8$ ), then this data is transferred to the  $\mu$ SR while the MSR is restored to its pre-interrupt state (second instruction  $00_8$ ).

In controllers and some other microprogrammed machines the applications program itself is often in the microprogram memory; that is, there is no macroinstruction set. These machines require only a microstatus register since there is no separate machine status. The MSR in the Am2904 can be used as a one-level stack on the microstatus register. When an interrupt occurs, the  $\mu$ SR and the MSR are simply swapped ( $I_5=0 = 02_8$ ).

2

### ORDERING INFORMATION

Order the part number according to the table below to obtain the desired package, temperature range, and operating level.

| Order Number | Package Type (Note 1) | Operating Range (Note 2) | Operating Level (Note 3)    |
|--------------|-----------------------|--------------------------|-----------------------------|
| AM2904C      | P-40                  | C                        | C-1                         |
| AM2904D      | D-40                  | C                        | C-1                         |
| AM2904C-B    | D-40                  | C                        | B-3 (Note 4)                |
| AM2904D-M    | D-40                  | M                        | C-2                         |
| AM2904D-B    | D-40                  | M                        | B-3                         |
| AM2904F-M    | T-40                  | M                        | C-2                         |
| AM2904F-B    | T-40                  | M                        | B-3                         |
| AM2904C-D    | Die                   | C                        | to MIL-STD-883C Method 2045 |
| AM2904D-M    | Die                   | M                        | to MIL-STD-883C Method 2045 |

Notes:  
1. P = Plastic DIP, D = Hermetic DIP, F = Flat Pack. Number follows number of number of leads. See Appendix B for detailed ordering information.  
2. When Appendix B contains several data numbers, any of the variations of the package may be used unless otherwise specified.  
3. C =  $-55^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ , VCC =  $+1.5\text{V}$  to  $+2.5\text{V}$ .  
M =  $-55^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ , VCC =  $+1.5\text{V}$  to  $+2.5\text{V}$ .  
4. See Appendix A for details of screening levels C-1 and C-2 conformance to MIL-STD-883. Class C level B-3 conformance to MIL-STD-883 Class B.

|   |   |  |  |
|---|---|--|--|
| $I_C$   | Am2901. Carry status input pin, intended for connection to the $C_{n+4}$ output of the most significant ALU slice.  | CT   | The conditional test output. The output of the Condition Code multiplexer appears here.  |
| $I_N$   | Sign status input pin, intended for connection to the most significant ALU slice. The connection is to the N pin on the Am2903, and the $F_3$ pin on the Am2901.  | $\overline{OE}_{CT}$                           | When this pin is LOW, the CT pin is active. When HIGH the CT pin is in the high impedance state.   |
| $I_{OVR}$   | Overflow status input pin, intended for connection to the OVR pin on the most significant ALU slice.  | $SIO_0$ ,<br>$SIO_n$ ,<br>$QIO_0$ ,<br>$QIO_n$ | These pins complete the linking for the various shift and rotate conditions. $SIO_0$ is intended for connection to the $SIO_0$ pin of the least significant Am2903 slice ( $RAM_0$ for Am2901). $SIO_n$ connects to the $SIO_3$ pin of the most significant Am2903 slice, ( $RAM_3$ for Am2901). $QIO_0$ connects to the $QIO_0$ pin of the least significant Am2903 slice ( $QIO_0$ for Am2901) and $QIO_n$ connects to the $QIO_3$ pin of the most significant Am2903 slice ( $Q_3$ for Am2901). |
| $I_0-12$  | The thirteen instruction pins which select the operation the Am2904 is to perform.  | $\overline{SE}$                                | This pin controls the state of the shift outputs. When LOW, the shift outputs are enabled. When HIGH, the shift outputs are in the high impedance state.   |
| $\overline{CE}_M$   | This pin, used in conjunction with $\overline{E}_Z$ , $\overline{E}_C$ , $\overline{E}_N$ , $\overline{E}_{OVR}$ acts as the overall enable for the machine status register. When the pin is LOW, MSR bits may be modified, according to the states of $\overline{E}_Z$ , $\overline{E}_C$ , $\overline{E}_N$ , $\overline{E}_{OVR}$ . When HIGH, the MSR will retain the present state, regardless of the state of $\overline{E}_Z$ , $\overline{E}_C$ , $\overline{E}_N$ , $\overline{E}_{OVR}$ . | $C_0$  | This pin is the output of the Carry In control multiplexer. It connects to the $C_n$ input of the least significant ALU slice, and the $C_n$ input of the Am2902A.   |
| $\overline{E}_Z$ , $\overline{E}_C$ ,<br>$\overline{E}_N$ ,<br>$\overline{E}_{OVR}$ | These pins, when LOW, enable the corresponding bits in the Machine Status Register. When HIGH, they will prevent the corresponding bits from changing state. By using these pins together with the $\overline{CE}_M$ pin, MSR bits can be selectively modified.   | $C_X$  | This pin is used as an input to the Carry In Control multiplexer which can route it to the $C_0$ pin. The $C_X$ pin is intended for connection to the Z output of the Am2903 to facilitate some of the Am2903 special instructions.  |
| $\overline{CE}_\mu$   | This pin, when LOW, enables all four bits of the Micro Status Register. When this pin is HIGH, the $\mu$ SR will not change state.  | CP   | The clock input to the device. The $\mu$ SR and MSR are modified on the LOW to HIGH transition of the clock input. All other portions of the Am2904 are combinational and are unaffected by CP.  |
| $Y_Z$ , $Y_C$ ,<br>$Y_N$ ,<br>$Y_{OVR}$   | These pins form a three-state bidirectional bus over which MSR and $\mu$ SR status can be read out or the MSR can be loaded in parallel.  |  |  |

#### ORDERING INFORMATION

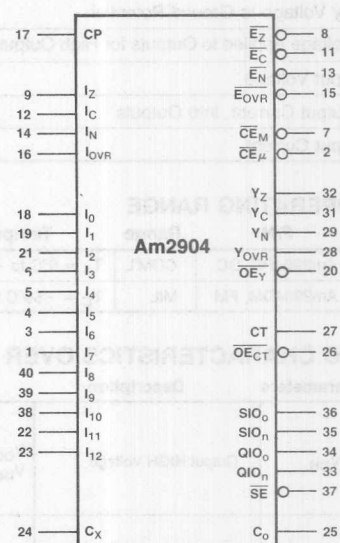
Order the part number according to the table below to obtain the desired package, temperature range, and screening level.

| Order Number | Package Type (Note 1) | Operating Range (Note 2) | Screening Level (Note 3)                       |
|--------------|-----------------------|--------------------------|--|
| AM2904PC     | P-40                  | C                        | C-1  |
| AM2904DC     | D-40                  | C                        | C-1  |
| AM2904DC-B   | D-40                  | C                        | B-2 (Note 4)                                   |
| AM2904DM     | D-40                  | M                        | C-3  |
| AM2904DM-B   | D-40                  | M                        | B-3  |
| AM2904FM     | F-42                  | M                        | C-3  |
| AM2904FM-B   | F-42                  | M                        | B-3  |
| AM2904XC     | Dice                  | C                        | Visual inspection to MIL-STD-883 Method 2010B. |
| AM2904XM     | Dice                  | M                        |  |

#### Notes:

1. P = Molded DIP, D = Hermetic DIP, F = Flat Pak. Number following letter is number of leads. See Appendix B for detailed outline. Where Appendix B contains several dash numbers, any of the variations of the package may be used unless otherwise specified.
2. C = 0°C to +70°C,  $V_{CC}$  = 4.75V to 5.25V.  
M = -55°C to +125°C,  $V_{CC}$  = 4.50V to 5.50V.
3. See Appendix A for details of screening. Levels C-1 and C-3 conform to MIL-STD-883, Class C. Level B-3 conforms to MIL-STD-883, Class B.
4. 96 hour burn-in.

**LOGIC SYMBOL  
(DIP)**



V<sub>CC</sub> = Pin 10  
GND = Pin 30

MPR-725

2-93

## Am2904

### MAXIMUM RATINGS (Above which the useful life may be impaired)

|   |                        |
|---|------------------------|
| Storage Temperature                                 | -65°C to +150°C        |
| Temperature (Case) Under Bias                       | -55°C to +125°C        |
| Supply Voltage to Ground Potential                  | -0.5V to +7.0V         |
| DC Voltage Applied to Outputs for High Output State | -0.5V to $V_{CC}$ max. |
| DC Input Voltage                                    | -0.5V to +5.5V         |
| DC Output Current, Into Outputs                     | 30mA                   |
| DC Input Current                                    | -30mA to +5.0mA        |

### OPERATING RANGE

| P/N          | Range | Temperature                                      | $V_{CC}$  |
|--------------|-------|--|---|
| Am2904PC, DC | COM'L | $T_A = 0^\circ\text{C to } +70^\circ\text{C}$    | $V_{CC} = 5.0V \pm 5\%$ (MIN. = 4.75V, MAX. = 5.25V)  |
| Am2904DM, FM | MIL   | $T_C = -55^\circ\text{C to } +125^\circ\text{C}$ | $V_{CC} = 5.0V \pm 10\%$ (MIN. = 4.50V, MAX. = 5.50V) |

### DC CHARACTERISTICS OVER OPERATING RANGE

| Parameters             | Description                               | Test Conditions (Note 1)                                      | Min.  | Typ.<br>(Note 2)   | Max.                                    | Units         |
|------------------------|---|---|---|--|---|---------------|
| $V_{OH}$               | Output HIGH Voltage                       | $V_{CC} = \text{MIN.}, V_{IN} = V_{IH} \text{ or } V_{IL}$    | $I_{OH} = -1.6\text{mA}$<br>$Y_Z, Y_C, Y_N, Y_{OVR}$  | 2.4  |   | Volts         |
|                        |   |   | $I_{OH} = -0.8\text{mA}$<br>$SIO_o, SIO_n, QIO_o, QIO_n, CT, CO$  | 2.4  |   | Volts         |
| $V_{OL}$               | Output LOW Voltage                        | $V_{CC} = \text{MIN.}, V_{IN} = V_{IH} \text{ or } V_{IL}$    | $Y_Z, Y_C$<br>$Y_N, Y_{OVR}$  |  | 0.5                                     | Volts         |
|                        |   |   | $I_{OL} = 24\text{mA (Com'l)}$<br>$I_{OL} = 16\text{mA (MIL)}$  |  | 0.5                                     | Volts         |
|                        |   |   | $SIO_o, QIO_o, CT, SIO_n, QIO_n, CO$<br>$I_{OL} = 8\text{mA}$   |  | 0.5                                     | Volts         |
| $V_{IH}$               | Input HIGH Voltage                        | Guaranteed Input Logical HIGH Voltage for all Inputs (Note 7) | 2.0   |  |   | Volts         |
| $V_{IL}$               | Input LOW Voltage                         | Guaranteed Input Logical LOW Voltage for all Inputs (Note 7)  |   |  | 0.8                                     | Volts         |
| $V_I$                  | Input Clamp Voltage                       | $V_{CC} = \text{MIN.}, I_{IN} = -18\text{mA}$                 |   |  | -1.5                                    | Volts         |
| $I_{IL}$               | Input LOW Current                         | $V_{CC} = \text{MAX.}, V_{IN} = 0.5V$                         | CP<br>$\overline{CE}_m, \overline{CE}_\mu$<br>$I_Z, I_C, I_N, I_{OVR}$  |  | -0.7<br>-1.8<br>-1.2                    | mA            |
|                        |   |   | $I_0, I_{12}, E_Z, E_C, E_N$<br>$E_{OVR}, OE_Y, OE_{CT}, C_X, Y_Z, Y_C, Y_N, Y_{OVR}$   |  | -0.45                                   | mA            |
|                        |   |   | $SE, SIO_o, SIO_n, QIO_o, QIO_n$  |  | -1.35                                   | mA            |
| $I_{IH}$               | Input HIGH Current                        | $V_{CC} = \text{MAX.}, V_{IN} = 2.7V$                         | CP, $I_0, I_{12}, E_Z, E_C, E_N$<br>$E_{OVR}, OE_Y, OE_{CT}, C_X$<br>$\overline{CE}_m, \overline{CE}_\mu$<br>$I_Z, I_C, I_N, I_{OVR}, SE$<br>$SIO_o, SIO_n, QIO_o, QIO_n$<br>$Y_Z, Y_C, Y_N, Y_{OVR}$ |  | 20<br>80<br>60<br>110<br>70             | $\mu\text{A}$ |
| $I_I$                  | Input HIGH Current                        | $V_{CC} = \text{MAX.}, V_{IN} = 5.5V$                         |   |  | 1.0                                     | mA            |
| $I_{OZH}$<br>$I_{OZL}$ | Off State (High Impedance) Output Current | $V_{CC} = \text{MAX.}$  | CT<br>$SIO_o, SIO_n, SIO_o, QIO_n$ (Note 4)<br>$Y_Z, Y_C, Y_N, Y_{OVR}$ (Note 4)  | $V_O = 2.4$<br>$V_O = 0.5$<br>$V_O = 2.4$<br>$V_O = 0.5$ | 50<br>-50<br>110<br>-1350<br>70<br>-450 | $\mu\text{A}$ |
| $I_{OS}$               | Output Short Circuit Current (Note 3)     | $V_{CC} = 5.75V, V_O = 0.5V$                                  |   | -30  | -85                                     | mA            |
| $I_{CC}$               | Power Supply Current (Note 6)             | $V_{CC} = \text{MAX.}$  | $T_A = 25^\circ\text{C}$<br>$T_A = 0^\circ\text{C to } +70^\circ\text{C}$<br>$T_A = +70^\circ\text{C}$<br>$T_C = -55^\circ\text{C to } +125^\circ\text{C}$<br>$T_C = +125^\circ\text{C}$              | 180<br>318<br>262<br>346<br>220                          | 296<br>318<br>262<br>346<br>220         | mA            |

- Notes: 1. For conditions shown as MIN. or MAX., use the appropriate value specified under Electrical Characteristics for the applicable device type.  
2. Typical limits are at  $V_{CC} = 5.0V$ ,  $25^\circ\text{C}$  ambient and maximum loading.  
3. Not more than one output should be shorted at a time. Duration of the short circuit test should not exceed one second.  
4. These are three-state outputs internally connected to TTL inputs. Input Characteristics are measured with output enables HIGH.  
5. "MIL" = Am2904 XM, DM, FM. "COM'L" = Am2904 XC, PC, DC.  
6. Worst case  $I_{CC}$  is at minimum temperature.  
7. These input levels provide zero noise immunity and should only be tested in a static, noise-free environment.



## SWITCHING CHARACTERISTICS

The tables below define the Am2904 switching characteristics. Tables A are set-up and hold times relative to the clock LOW-to-HIGH transition. Tables B are combinational delays. Tables C are clock requirements. All measurements are made at 1.5V with input levels at 0V or 3V. All values are in ns. All outputs have maximum DC loading.

TYPICAL ROOM TEMPERATURE CHARACTERISTICS ( $T_A = 25^\circ\text{C}$ ,  $V_{CC} = 5.0\text{V}$ ,  $C_L = 50\text{pF}$ )

## A. Set-up and Hold Times (ns)

| Input  | $t_s$ | $t_h$ |
|--|-------|-------|
| $I_Z, I_N, I_{OVR}$  | 8     | 2     |
| $I_C (I_1 I_2 I_3 \neq 001)$   | 20    | 1     |
| $I_C (I_1 I_2 I_3 = 001)$  | 8     | 1     |
| $\overline{CE}_\mu$  | 12    | 0     |
| $\overline{CE}_M$  | 16    | 0     |
| $\overline{E}_Z, \overline{E}_C, \overline{E}_N, \overline{E}_{OVR}$ | 14    | 0     |
| $I_0-I_5$  | 29    | 0     |
| $I_6-I_{10}$   | 30    | 0     |
| $\overline{SE}$  | 26    | 0     |
| $Y_Z, Y_C, Y_N, Y_{OVR}$<br>( $I_0-I_5 = \text{LOW}$ )               | 9     | 0     |
| $SIO_0, SIO_n, QIO_0$  | 10    | 0     |

## B. Combinational Delays (ns)

| From (Input)             | To (Output)                  | $t_{pd}$ |
|--------------------------|------------------------------|----------|
| $I_Z, I_C, I_N, I_{OVR}$ | $Y_Z, Y_C, Y_N, Y_{OVR}$     | 27       |
| CP                       | $Y_Z, Y_C, Y_N, Y_{OVR}$     | 38       |
| $I_4, I_5$               | $Y_Z, Y_C, Y_N, Y_{OVR}$     | 32       |
| $I_Z, I_C, I_N, I_{OVR}$ | CT                           | 35       |
| CP                       | CT                           | 43       |
| $I_0-I_5$                | CT                           | 38       |
| $C_X$                    | $C_O$                        | 13       |
| CP                       | $C_O$                        | 28       |
| $I_{1,2,3,5,11,12}$      | $C_O$                        | 28       |
| $SIO_n, QIO_n$           | $SIO_0$                      | 17       |
| $SIO_0, QIO_0$           | $SIO_n$                      | 16       |
| $I_C, I_N, I_{OVR}$      | $SIO_n$                      | 23       |
| $SIO_n, QIO_n$           | $QIO_0$                      | 18       |
| $SIO_0, QIO_0$           | $QIO_n$                      | 16       |
| CP                       | $SIO_0, SIO_n, QIO_0, QIO_n$ | 29       |
| $I_6-I_{10}$             | $SIO_0, SIO_n, QIO_0, QIO_n$ | 23       |

## C. Clock Requirements (ns)

|                         |    |
|-------------------------|----|
| Minimum Clock LOW Time  | 10 |
| Minimum Clock HIGH Time | 10 |

## D. Enable/Disable Times (ns)

$C_L = 5.0\text{pF}$  for Output Disable Tests

| From (Input)         | To (Output)                  | Enable | Disable |
|----------------------|------------------------------|--------|---------|
| $\overline{OE}_{CT}$ | CT                           | 13     | 10      |
| $\overline{SE}$      | $SIO_0, SIO_n, QIO_0, QIO_n$ | 21     | 8       |
| $I_{10}$             | $SIO_0, SIO_n, QIO_0, QIO_n$ | 30     | 20      |
| $\overline{OE}_Y$    | $Y_Z, Y_C, Y_N, Y_{OVR}$     | 16     | 12      |
| $I_0-I_5$            | $Y_Z, Y_C, Y_N, Y_{OVR}$     | 23     | 25      |

GUARANTEED ROOM TEMPERATURE CHARACTERISTICS ( $T_A = 25^\circ\text{C}$ ,  $V_{CC} = 5.0\text{V}$ ,  $C_L = 50\text{pF}$ )

(Group A, Subgroup 9 Tests)

## A. Set-up and Hold Times (ns)

| Input  | $t_s$ | $t_h$ |
|--|-------|-------|
| $I_Z, I_N, I_{OVR}$  | 15    | 5     |
| $I_C (I_1 I_2 I_3 \neq 001)$   | 26    | 5     |
| $I_C (I_1 I_2 I_3 = 001)$  | 15    | 5     |
| $\overline{CE}_\mu$  | 19    | 5     |
| $\overline{CE}_M$  | 22    | 5     |
| $\overline{E}_Z, \overline{E}_C, \overline{E}_N, \overline{E}_{OVR}$ | 20    | 5     |
| $I_0-I_5$  | 37    | 0     |
| $I_6-I_{10}$   | 38    | 0     |
| $\overline{SE}$  | 33    | 0     |
| $Y_Z, Y_C, Y_N, Y_{OVR}$<br>( $I_0-I_5 = \text{LOW}$ )               | 15    | 5     |
| $SIO_0, SIO_n, QIO_0$  | 17    | 5     |

## B. Combinational Delays (ns)

| From (Input)             | To (Output)                  | $t_{pd}$ |
|--------------------------|------------------------------|----------|
| $I_Z, I_C, I_N, I_{OVR}$ | $Y_Z, Y_C, Y_N, Y_{OVR}$     | 35       |
| CP                       | $Y_Z, Y_C, Y_N, Y_{OVR}$     | 46       |
| $I_4, I_5$               | $Y_Z, Y_C, Y_N, Y_{OVR}$     | 43       |
| $I_Z, I_C, I_N, I_{OVR}$ | CT                           | 43       |
| CP                       | CT                           | 54       |
| $I_0-I_5$                | CT                           | 47       |
| $C_X$                    | $C_O$                        | 20       |
| CP                       | $C_O$                        | 36       |
| $I_{1,2,3,5,11,12}$      | $C_O$                        | 36       |
| $SIO_n, QIO_n$           | $SIO_0$                      | 23       |
| $SIO_0, QIO_0$           | $SIO_n$                      | 23       |
| $I_C, I_N, I_{OVR}$      | $SIO_n$                      | 30       |
| $SIO_n, QIO_n$           | $QIO_0$                      | 25       |
| $SIO_0, QIO_0$           | $QIO_n$                      | 22       |
| CP                       | $SIO_0, SIO_n, QIO_0, QIO_n$ | 37       |
| $I_6-I_{10}$             | $SIO_0, SIO_n, QIO_0, QIO_n$ | 30       |

## C. Clock Requirements (ns)

|                         |    |
|-------------------------|----|
| Minimum Clock LOW Time  | 25 |
| Minimum Clock HIGH Time | 25 |

## D. Enable/Disable Times (ns)

$C_L = 5.0\text{pF}$  for Output Disable Tests

| From (Input)         | To (Output)                  | Enable | Disable |
|----------------------|------------------------------|--------|---------|
| $\overline{OE}_{CT}$ | CT                           | 20     | 16      |
| $\overline{SE}$      | $SIO_0, SIO_n, QIO_0, QIO_n$ | 29     | 14      |
| $I_{10}$             | $SIO_0, SIO_n, QIO_0, QIO_n$ | 38     | 24      |
| $\overline{OE}_Y$    | $Y_Z, Y_C, Y_N, Y_{OVR}$     | 22     | 19      |
| $I_0-I_5$            | $Y_Z, Y_C, Y_N, Y_{OVR}$     | 38     | 32      |

# **GUARANTEED CHARACTERISTICS OVER COMMERCIAL OPERATING RANGE**

( $T_A = 0^\circ\text{C}$  to  $+70^\circ\text{C}$ ,  $V_{CC} = 4.75\text{V}$  to  $5.25\text{V}$ ,  $C_L = 50\text{pF}$ )

## **A. Set-up and Hold Times (ns)**

| Input  | $t_s$ | $t_h$ |
|--|-------|-------|
| $I_Z, I_N, I_{OVR}$  | 27    | 5     |
| $I_C$ ( $I_1, I_2, I_3 \neq 001$ )                                   | 28    | 5     |
| $I_C$ ( $I_1, I_2, I_3 = 001$ )                                      | 17    | 5     |
| $\overline{CE}_\mu$  | 20    | 5     |
| $\overline{CE}_M$  | 25    | 5     |
| $\overline{E}_Z, \overline{E}_C, \overline{E}_N, \overline{E}_{OVR}$ | 23    | 5     |
| $I_0$ - $I_5$  | 41    | 0     |
| $I_6$ - $I_{10}$   | 40    | 0     |
| $\overline{SE}$  | 36    | 0     |
| $Y_Z, Y_C, Y_N, Y_{OVR}$<br>( $I_0$ - $I_5 = \text{LOW}$ )           | 18    | 5     |
| $SIO_0, SIO_n, QIO_0$  | 19    | 5     |

## **B. Combinational Delays (ns)**

| From (Input)             | To (Output)                  | $t_{pd}$ |
|--------------------------|------------------------------|----------|
| $I_Z, I_C, I_N, I_{OVR}$ | $Y_Z, Y_C, Y_N, Y_{OVR}$     | 38       |
| CP                       | $Y_Z, Y_C, Y_N, Y_{OVR}$     | 50       |
| $I_4, I_5$               | $Y_Z, Y_C, Y_N, Y_{OVR}$     | 43       |
| $I_Z, I_C, I_N, I_{OVR}$ | CT                           | 48       |
| CP                       | CT                           | 58       |
| $I_0$ - $I_5$            | CT                           | 50       |
| $C_X$                    | $C_O$                        | 20       |
| CP                       | $C_O$                        | 37       |
| $I_{1,2,3,5,11,12}$      | $C_O$                        | 37       |
| $SIO_n, QIO_n$           | $SIO_0$                      | 25       |
| $SIO_0, QIO_0$           | $SIO_n$                      | 24       |
| $I_C, I_N, I_{OVR}$      | $SIO_n$                      | 32       |
| $SIO_n, QIO_n$           | $QIO_0$                      | 26       |
| $SIO_0, QIO_0$           | $QIO_n$                      | 23       |
| CP                       | $SIO_0, SIO_n, QIO_0, QIO_n$ | 39       |
| $I_6$ - $I_{10}$         | $SIO_0, SIO_n, QIO_0, QIO_n$ | 32       |

## **C. Clock Requirements (ns)**

|                         |    |
|-------------------------|----|
| Minimum Clock LOW Time  | 30 |
| Minimum Clock HIGH Time | 30 |

## **D. Enable/Disable Times (ns)**

$C_L = 5.0\text{pF}$  for Output Disable Tests

| From (Input)         | To (Output)                  | Enable | Disable |
|----------------------|------------------------------|--------|---------|
| $\overline{OE}_{CT}$ | CT                           | 23     | 18      |
| $\overline{SE}$      | $SIO_0, SIO_n, QIO_0, QIO_n$ | 34     | 16      |
| $I_{10}$             | $SIO_0, SIO_n, QIO_0, QIO_n$ | 44     | 33      |
| $\overline{OE}_Y$    | $Y_Z, Y_C, Y_N, Y_{OVR}$     | 28     | 21      |
| $I_0$ - $I_5$        | $Y_Z, Y_C, Y_N, Y_{OVR}$     | 43     | 41      |

# **GUARANTEED CHARACTERISTICS OVER MILITARY OPERATING RANGE**

( $T_C = -55^\circ\text{C}$  to  $+125^\circ\text{C}$ ,  $V_{CC} = 4.5\text{V}$  to  $5.5\text{V}$ ,  $C_L = 50\text{pF}$ )

## **A. Set-up and Hold Times (ns)**

| Input  | $t_s$ | $t_h$ |
|--|-------|-------|
| $I_Z, I_N, I_{OVR}$  | 17    | 8     |
| $I_C$ ( $I_1, I_2, I_3 \neq 001$ )                                   | 28    | 7     |
| $I_C$ ( $I_1, I_2, I_3 = 001$ )                                      | 18    | 6     |
| $\overline{CE}_\mu$  | 20    | 4     |
| $\overline{CE}_M$  | 25    | 6     |
| $\overline{E}_Z, \overline{E}_C, \overline{E}_N, \overline{E}_{OVR}$ | 23    | 6     |
| $I_0$ - $I_5$  | 48    | 0     |
| $I_6$ - $I_{10}$   | 44    | 2     |
| $\overline{SE}$  | 40    | 0     |
| $Y_Z, Y_C, Y_N, Y_{OVR}$<br>( $I_0$ - $I_5 = \text{LOW}$ )           | 18    | 6     |
| $SIO_0, SIO_n, QIO_0$  | 19    | 6     |

## **B. Combinational Delays (ns)**

| From (Input)             | To (Output)                  | $t_{pd}$ |
|--------------------------|------------------------------|----------|
| $I_Z, I_C, I_N, I_{OVR}$ | $Y_Z, Y_C, Y_N, Y_{OVR}$     | 40       |
| CP                       | $Y_Z, Y_C, Y_N, Y_{OVR}$     | 50       |
| $I_4, I_5$               | $Y_Z, Y_C, Y_N, Y_{OVR}$     | 43       |
| $I_Z, I_C, I_N, I_{OVR}$ | CT                           | 55       |
| CP                       | CT                           | 67       |
| $I_0$ - $I_5$            | CT                           | 65       |
| $C_X$                    | $C_O$                        | 24       |
| CP                       | $C_O$                        | 38       |
| $I_{1,2,3,5,11,12}$      | $C_O$                        | 43       |
| $SIO_n, QIO_n$           | $SIO_0$                      | 27       |
| $SIO_0, QIO_0$           | $SIO_n$                      | 27       |
| $I_C, I_N, I_{OVR}$      | $SIO_n$                      | 35       |
| $SIO_n, QIO_n$           | $QIO_0$                      | 28       |
| $SIO_0, QIO_0$           | $QIO_n$                      | 28       |
| CP                       | $SIO_0, SIO_n, QIO_0, QIO_n$ | 39       |
| $I_6$ - $I_{10}$         | $SIO_0, SIO_n, QIO_0, QIO_n$ | 32       |

## **C. Clock Requirements (ns)**

|                         |    |
|-------------------------|----|
| Minimum Clock LOW Time  | 30 |
| Minimum Clock HIGH Time | 30 |

## **D. Enable/Disable Times (ns)**

$C_L = 5.0\text{pF}$  for Output Disable Tests

| From (Input)         | To (Output)                  | Enable | Disable |
|----------------------|------------------------------|--------|---------|
| $\overline{OE}_{CT}$ | CT                           | 25     | 18      |
| $\overline{SE}$      | $SIO_0, SIO_n, QIO_0, QIO_n$ | 34     | 16      |
| $I_{10}$             | $SIO_0, SIO_n, QIO_0, QIO_n$ | 44     | 33      |
| $\overline{OE}_Y$    | $Y_Z, Y_C, Y_N, Y_{OVR}$     | 28     | 21      |
| $I_0$ - $I_5$        | $Y_Z, Y_C, Y_N, Y_{OVR}$     | 43     | 41      |

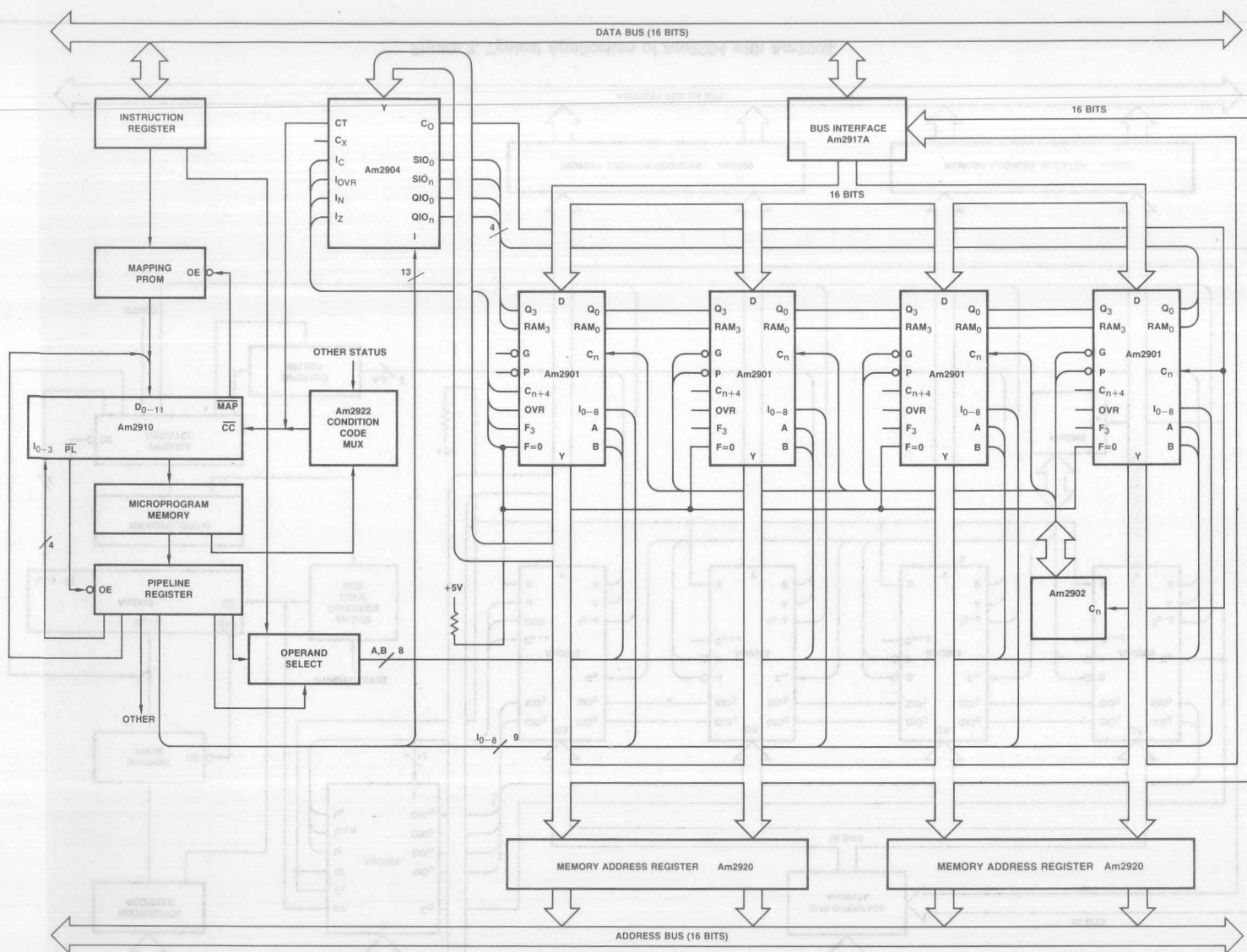


Figure 1. Typical Application of Am2904 with Am2901.

**Figure 2. Typical Application of Am2904 with Am2903.**



# Am2905

## Quad Two-Input OC Bus Transceiver With Three-State Receiver

### Distinctive Characteristics

- Quad high-speed LSI bus-transceiver
- Open-collector bus driver
- Two-port input to D-type register on driver
- Bus driver output can sink 100 mA at 0.8V max.

- Receiver has output latch for pipeline operation
- Three-state receiver outputs sink 12 mA
- Advanced low-power Schottky processing
- 100% reliability assurance testing in compliance with MIL-STD-883

### FUNCTIONAL DESCRIPTION

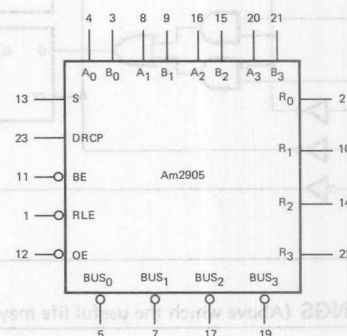
The Am2905 is a high-performance, low-power Schottky bus transceiver intended for bipolar or MOS microprocessor system applications. The device consists of four D-type edge-triggered flip-flops with a built-in two-input multiplexer on each. The flip-flop outputs are connected to four open-collector bus drivers. Each bus driver is internally connected to one input of a differential amplifier in the receiver. The four receiver differential amplifier outputs drive four D-type latches that feature three-state outputs.

This LSI bus transceiver is fabricated using advanced low-power Schottky processing. All inputs (except the BUS inputs) are one LS unit load. The open-collector bus output can sink up to 100 mA at 0.8V maximum. The BUS input differential amplifier contains disconnect protection diodes such that the bus is fail-safe when power is not applied. The bus enable input ( $\overline{BE}$ ) is used to force the driver outputs to the high-impedance state. When  $\overline{BE}$  is HIGH, the driver is disabled. The open-collector structure of the driver allows wired-OR operations to be performed on the bus.

The input register consists of four D-type flip-flops with a buffered common clock and a two-input multiplexer at the input of each flip-flop. A common select input (S) controls the four multiplexers. When S is LOW, the  $A_i$  data is stored in the register and when S is HIGH, the  $B_i$  data is stored. The buffered common clock (DRCP) enters the data into this driver register on the LOW-to-HIGH transition.

Data from the A or B inputs is inverted at the BUS output. Likewise, data at the BUS input is inverted at the receiver output. Thus, data is non-inverted from driver input to receiver output. The four receivers each feature a built-in D-type latch that is controlled from the buffered receiver latch enable ( $\overline{RLE}$ ) input. When the  $\overline{RLE}$  input is LOW, the latch is open and the receiver outputs will follow the bus inputs (BUS data inverted and  $\overline{OE}$  LOW). When the  $\overline{RLE}$  input is HIGH, the latch will close and retain the present data regardless of the bus input. The four latches have three-state outputs and are controlled by a buffered common three-state control ( $\overline{OE}$ ) input. When  $\overline{OE}$  is HIGH, the receiver outputs are in the high-impedance state.

### LOGIC SYMBOL



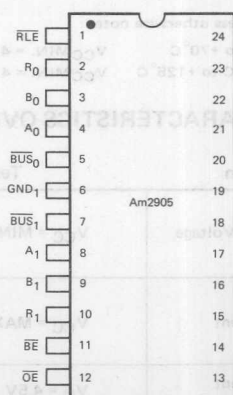
$V_{CC}$  = Pin 24

$GND_1$  = Pin 6

$GND_2$  = Pin 18

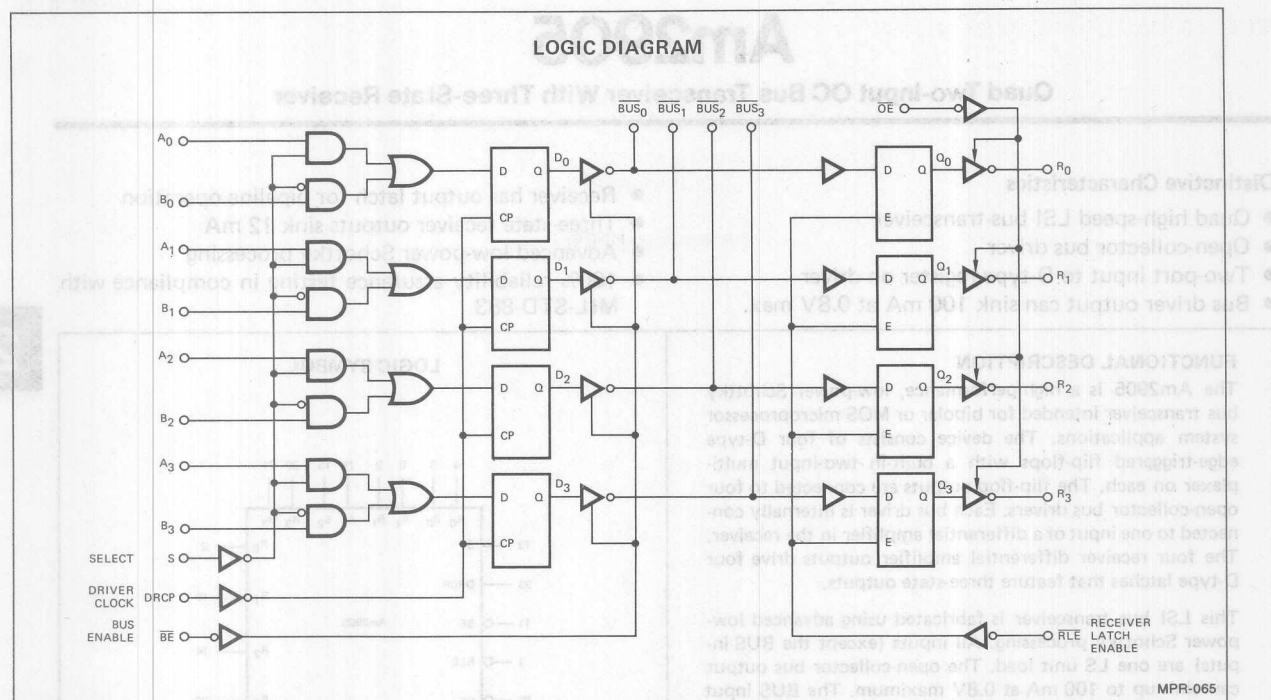
MPR-063

### CONNECTION DIAGRAM Top View



Note: Pin 1 is marked for orientation.

MPR-064

**MAXIMUM RATINGS** (Above which the useful life may be impaired)

|   |                                |
|---|--------------------------------|
| Storage Temperature                                 | –65°C to +150°C                |
| Temperature (Ambient) Under Bias                    | –55°C to +125°C                |
| Supply Voltage to Ground Potential                  | –0.5V to +7V                   |
| DC Voltage Applied to Outputs for HIGH Output State | –0.5V to +V <sub>CC</sub> max. |
| DC Input Voltage                                    | –0.5V to +7V                   |
| DC Output Current, Into Outputs (Except Bus)        | 30mA                           |
| DC Output Current, Into Bus                         | 200mA                          |
| DC Input Current                                    | –30mA to +5.0mA                |

**ELECTRICAL CHARACTERISTICS**

The following conditions apply unless otherwise noted:

|                  |                                  |                              |                              |
|------------------|----------------------------------|------------------------------|------------------------------|
| Am2905XC (COM'L) | T <sub>A</sub> = 0°C to +70°C    | V <sub>CC</sub> MIN. = 4.75V | V <sub>CC</sub> MAX. = 5.25V |
| Am2905XM (MIL)   | T <sub>A</sub> = –55°C to +125°C | V <sub>CC</sub> MIN. = 4.50V | V <sub>CC</sub> MAX. = 5.50V |

**BUS INPUT/OUTPUT CHARACTERISTICS OVER OPERATING TEMPERATURE RANGE**

| Parameters       | Description                     | Test Conditions (Note 1) |                         | Min.  | Typ.<br>(Note 2) | Max. | Units |
|------------------|---------------------------------|--------------------------|-------------------------|-------|------------------|------|-------|
| V <sub>OL</sub>  | Bus Output LOW Voltage          | V <sub>CC</sub> = MIN.   | I <sub>OL</sub> = 40mA  |       | 0.32             | 0.5  | Volts |
|                  |                                 |                          | I <sub>OL</sub> = 70mA  |       | 0.41             | 0.7  |       |
|                  |                                 |                          | I <sub>OL</sub> = 100mA |       | 0.55             | 0.8  |       |
| I <sub>O</sub>   | Bus Leakage Current             | V <sub>CC</sub> = MAX.   | V <sub>O</sub> = 0.4V   |       |                  | –50  | μA    |
|                  |                                 |                          | V <sub>O</sub> = 4.5V   | MIL   |                  | 200  |       |
|                  |                                 |                          |                         | COM'L |                  | 100  |       |
| I <sub>OFF</sub> | Bus Leakage Current (Power OFF) | V <sub>O</sub> = 4.5V    |                         |       |                  | 100  | μA    |
| V <sub>TH</sub>  | Receiver Input HIGH Threshold   | Bus enable = 2.4V        | MIL                     | 2.4   | 2.0              |      | Volts |
|                  |                                 |                          | COM'L                   | 2.3   | 2.0              |      |       |
| V <sub>TL</sub>  | Receiver Input LOW Threshold    | Bus enable = 2.4V        | MIL                     |       | 2.0              | 1.5  | Volts |
|                  |                                 |                          | COM'L                   |       | 2.0              | 1.6  |       |

## ELECTRICAL CHARACTERISTICS

The following conditions apply unless otherwise noted:

Am2905XC (COM'L)  $T_A = 0^\circ\text{C to } +70^\circ\text{C}$   $V_{CC\text{ MIN.}} = 4.75\text{ V}$   $V_{CC\text{ MAX.}} = 5.25\text{ V}$   
 Am2905XM (MIL)  $T_A = -55^\circ\text{C to } +125^\circ\text{C}$   $V_{CC\text{ MIN.}} = 4.50\text{ V}$   $V_{CC\text{ MAX.}} = 5.50\text{ V}$

## DC CHARACTERISTICS OVER OPERATING TEMPERATURE RANGE

| Parameters | Description                           | Test Conditions (Note 1)                                |                                  | Min. | Typ.<br>(Note 2) | Max.  | Units         |
|------------|---------------------------------------|---|----------------------------------|------|------------------|-------|---------------|
| $V_{OH}$   | Receiver Output HIGH Voltage          | $V_{CC} = V_{IN}$<br>$V_{IN} = V_{IL}$ or $V_{IH}$      | MIL, $I_{OH} = -1.0\text{ mA}$   | 2.4  | 3.4              |       | Volts         |
|            |                                       |   | COM'L, $I_{OH} = -2.6\text{ mA}$ | 2.4  | 3.4              |       |               |
| $V_{OL}$   | Receiver Output LOW Voltage           | $V_{CC} = \text{MIN.}$<br>$V_{IN} = V_{IL}$ or $V_{IH}$ | $I_{OL} = 4\text{ mA}$           |      | 0.27             | 0.4   | Volts         |
|            |                                       |   | $I_{OL} = 8\text{ mA}$           |      | 0.32             | 0.45  |               |
|            |                                       |   | $I_{OL} = 12\text{ mA}$          |      | 0.37             | 0.5   |               |
| $V_{IH}$   | Input HIGH Level (Except Bus)         | Guaranteed input logical HIGH for all inputs            |                                  | 2.0  |                  |       | Volts         |
| $V_{IL}$   | Input LOW Level (Except Bus)          | Guaranteed input logical LOW for all inputs             | MIL                              |      |                  | 0.7   | Volts         |
|            |                                       |   | COM'L                            |      |                  | 0.8   |               |
| $V_I$      | Input Clamp Voltage (Except Bus)      | $V_{CC} = \text{MIN.}$ , $I_{IN} = -18\text{ mA}$       |                                  |      |                  | -1.5  | Volts         |
| $I_{IL}$   | Input LOW Current (Except Bus)        | $V_{CC} = \text{MAX.}$ , $V_{IN} = 0.4\text{ V}$        |                                  |      |                  | -0.36 | mA            |
| $I_{IH}$   | Input HIGH Current (Except Bus)       | $V_{CC} = \text{MAX.}$ , $V_{IN} = 2.7\text{ V}$        |                                  |      |                  | 20    | $\mu\text{A}$ |
| $I_I$      | Input HIGH Current (Except Bus)       | $V_{CC} = \text{MAX.}$ , $V_{IN} = 5.5\text{ V}$        |                                  |      |                  | 100   | $\mu\text{A}$ |
| $I_O$      | Receiver Off-State Output Current     | $V_{CC} = \text{MAX.}$                                  | $V_O = 2.4\text{ V}$             |      |                  | 20    | $\mu\text{A}$ |
|            |                                       |   | $V_O = 0.4\text{ V}$             |      |                  | -20   |               |
| $I_{SC}$   | Receiver Output Short Circuit Current | $V_{CC} = \text{MAX.}$                                  |                                  | -12  |                  | -65   | mA            |
| $I_{CC}$   | Power Supply Current                  | $V_{CC} = \text{MAX.}$ , All inputs = GND               |                                  |      | 69               | 105   | mA            |

## SWITCHING CHARACTERISTICS OVER OPERATING TEMPERATURE RANGE

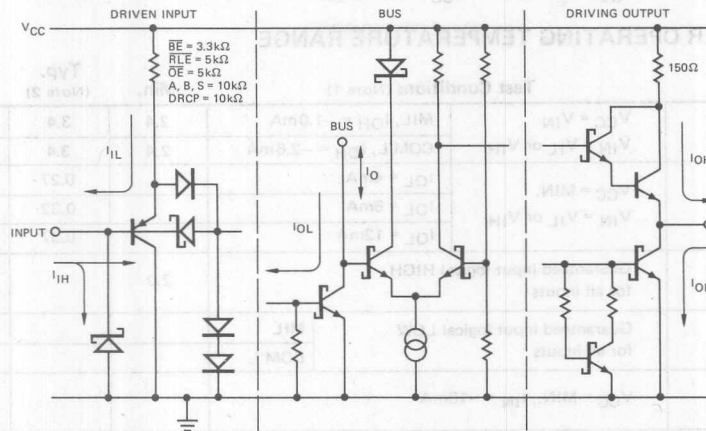
|                  |  |   | Am2905XM |          |      | Am2905XC |          |      |       |
|------------------|--|---|----------|----------|------|----------|----------|------|-------|
| Parameters       | Description                              | Test Conditions   | Typ.     |          |      | Typ.     |          |      | Units |
|                  |  |   | Min.     | (Note 2) | Max. | Min.     | (Note 2) | Max. |       |
| t <sub>PHL</sub> | Driver Clock (DRCP) to Bus               | C <sub>L</sub> (BUS) = 50pF<br>R <sub>L</sub> (BUS) = 50Ω |          | 21       | 40   |          | 21       | 36   | ns    |
| t <sub>PLH</sub> |  |   |          | 21       | 40   |          | 21       | 36   |       |
| t <sub>PHL</sub> | Bus Enable ( $\overline{BE}$ ) to Bus    |   |          | 13       | 26   |          | 13       | 23   | ns    |
| t <sub>PLH</sub> |  |   |          | 13       | 26   |          | 13       | 23   |       |
| t <sub>s</sub>   | Data Inputs (A or B)                     | C <sub>L</sub> = 15pF<br>R <sub>L</sub> = 2.0kΩ           | 25       |          |      | 23       |          |      | ns    |
| t <sub>h</sub>   |  |   | 8.0      |          |      | 7.0      |          |      |       |
| t <sub>s</sub>   | Select Input (S)                         |   | 33       |          |      | 30       |          |      | ns    |
| t <sub>h</sub>   |  |   | 8.0      |          |      | 7.0      |          |      |       |
| t <sub>PW</sub>  | Driver Clock (DRCP) Pulse Width (HIGH)   |   | 28       |          |      | 25       |          |      | ns    |
| t <sub>PLH</sub> | Bus to Receiver Output (Latch Enable)    |   |          | 18       | 37   |          | 18       | 34   | ns    |
| t <sub>PHL</sub> |  |   |          | 18       | 37   |          | 18       | 34   |       |
| t <sub>PLH</sub> | Latch Enable to Receiver Output          |   |          | 21       | 37   |          | 21       | 34   | ns    |
| t <sub>PHL</sub> |  |   |          | 21       | 37   |          | 21       | 34   |       |
| t <sub>s</sub>   | Bus to Latch Enable ( $\overline{RLE}$ ) |   | 21       |          |      | 18       |          |      | ns    |
| t <sub>h</sub>   |  |   | 7.0      |          |      | 5.0      |          |      |       |
| t <sub>ZH</sub>  | Output Control to Receiver Output        |   |          | 14       | 28   |          | 14       | 25   | ns    |
| t <sub>ZL</sub>  |  |   |          | 14       | 28   |          | 14       | 25   |       |
| t <sub>HZ</sub>  | Output Control to Receiver Output        |   |          | 14       | 28   |          | 14       | 25   | ns    |
| t <sub>LZ</sub>  |  |   |          | 14       | 28   |          | 14       | 25   |       |

Notes: 1. For conditions shown as MIN. or MAX., use the appropriate value specified under Electrical Characteristics for the applicable device type.

2. Typical limits are at  $V_{CC} = 5.0\text{ V}$ ,  $25^\circ\text{C}$  ambient and maximum loading.

3. Not more than one output should be shorted at a time. Duration of the short circuit test should not exceed one second.

# INPUT/OUTPUT CURRENT INTERFACE CONDITIONS

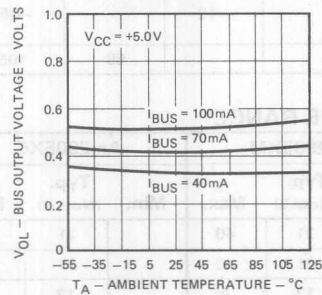


Note: Actual current flow direction shown.

MPR-066

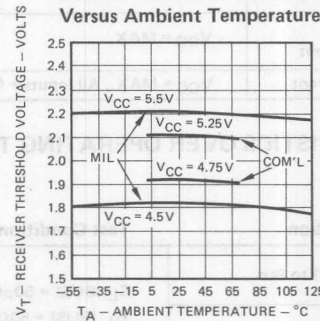
## TYPICAL PERFORMANCE CURVES

Bus Output Low Voltage  
Versus Ambient Temperature



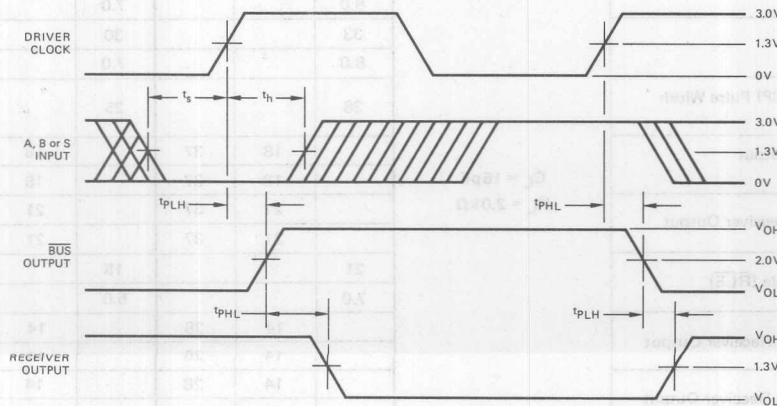
MPR-067

Receiver Threshold Variation  
Versus Ambient Temperature



MPR-068

## SWITCHING WAVEFORMS



Note: Bus to Receiver output delay is measured by clocking data into the driver register and measuring the BUS to R combinatorial delay.

MPR-069



## FUNCTION TABLE

| INPUTS |                |                |      |    |     | INTERNAL TO DEVICE |                | BUS            | OUTPUT           | FUNCTION |  |
|--------|----------------|----------------|------|----|-----|--------------------|----------------|----------------|------------------|----------|--|
| S      | A <sub>i</sub> | B <sub>i</sub> | DRCP | BE | RLE | OE                 | D <sub>i</sub> | Q <sub>i</sub> | BUS <sub>i</sub> |          | R <sub>i</sub>                                       |
| X      | X              | X              | X    | H  | X   | X                  | X              | X              | Z                | X        | Driver output disable                                |
| X      | X              | X              | X    | X  | X   | H                  | X              | X              | X                | Z        | Receiver output disable                              |
| X      | X              | X              | X    | H  | L   | L                  | X              | L              | L                | H        | Driver output disable and receive data via Bus input |
| X      | X              | X              | X    | H  | L   | L                  | X              | H              | H                | L        |  |
| X      | X              | X              | X    | X  | H   | X                  | X              | NC             | X                | X        | Latch received data                                  |
| L      | L              | X              | ↑    | X  | X   | X                  | L              | X              | X                | X        | Load driver register                                 |
| L      | H              | X              | ↑    | X  | X   | X                  | H              | X              | X                | X        |  |
| H      | X              | L              | ↑    | X  | X   | X                  | L              | X              | X                | X        |  |
| H      | X              | H              | ↑    | X  | X   | X                  | H              | X              | X                | X        |  |
| X      | X              | X              | L    | X  | X   | X                  | NC             | X              | X                | X        | No driver clock restrictions                         |
| X      | X              | X              | H    | X  | X   | X                  | NC             | X              | X                | X        |  |
| X      | X              | X              | X    | L  | X   | X                  | L              | X              | H                | X        | Drive Bus  |
| X      | X              | X              | X    | L  | X   | X                  | H              | X              | L                | X        |  |

H = HIGH  
L = LOW  
Z = HIGH Impedance  
NC = No change  
X = Don't care  
↑ = LOW to HIGH transition  
i = 0, 1, 2, 3

## ORDERING INFORMATION

Order the part number according to the table below to obtain the desired package, temperature range, and screening level.

| Order Number | Package Type (Note 1) | Operating Range (Note 2) | Screening Level (Note 3)                       |
|--------------|-----------------------|--------------------------|--|
| AM2905PC     | P-24                  | C                        | C-1  |
| AM2905DC     | D-24                  | C                        | C-1  |
| AM2905DC-B   | D-24                  | C                        | B-1  |
| AM2905DM     | D-24                  | M                        | C-3  |
| AM2905DM-B   | D-24                  | M                        | B-3  |
| AM2905FM     | F-24-1                | M                        | C-3  |
| AM2905FM-B   | F-24-1                | M                        | B-3  |
| AM2905XC     | Dice                  | C                        | Visual inspection to MIL-STD-883 Method 2010B. |
| AM2905XM     | Dice                  | M                        |  |

## Notes:

1. P = Molded DIP, D = Hermetic DIP, F = Flat Pak. Number following letter is number of leads. See Appendix B for detailed outline. Where Appendix B contains several dash numbers, any of the variations of the package may be used unless otherwise specified.
2. C = 0°C to +70°C,  $V_{CC}$  = 4.75V to 5.25V.  
M = -55°C to +125°C,  $V_{CC}$  = 4.50V to 5.50V.
3. See Appendix A for details of screening. Levels C-1 and C-3 conform to MIL-STD-883, Class C. Level B-3 conforms to MIL-STD-883, Class B.

## DEFINITION OF FUNCTIONAL TERMS

**A<sub>0</sub>, A<sub>1</sub>, A<sub>2</sub>, A<sub>3</sub>** The "A" word data input into the two input multiplexer of the driver register.

**B<sub>0</sub>, B<sub>1</sub>, B<sub>2</sub>, B<sub>3</sub>** The "B" word data input into the two input multiplexers of the driver register.

**S** Select. When the select input is LOW, the A data word is applied to the driver register. When the select input is HIGH, the B word is applied to the driver register.

**DRCP** Driver Clock Pulse. Clock pulse for the driver register.

**$\overline{BE}$**  Bus Enable. When the Bus Enable is HIGH, the four drivers are in the high impedance state.

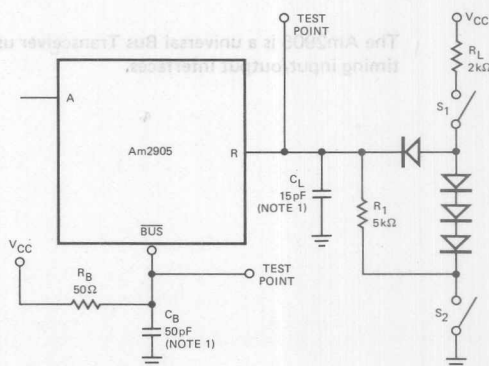
**$\overline{BUS}_0, \overline{BUS}_1, \overline{BUS}_2, \overline{BUS}_3$**  The four driver outputs and receiver inputs (data is inverted).

**R<sub>0</sub>, R<sub>1</sub>, R<sub>2</sub>, R<sub>3</sub>** The four receiver outputs. Data from the bus is inverted while data from the A or B inputs is non-inverted.

**$\overline{RLE}$**  Receiver Latch Enable. When  $\overline{RLE}$  is LOW, data on the BUS inputs is passed through the receiver latches. When  $\overline{RLE}$  is HIGH, the receiver latches are closed and will retain the data independent of all other inputs.

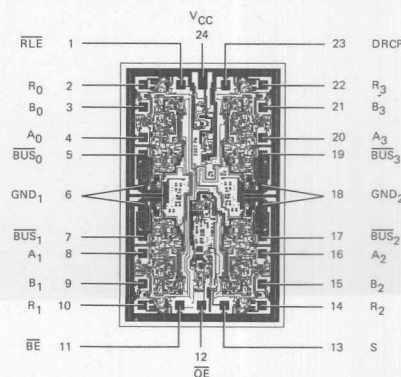
**$\overline{OE}$**  Output Enable. When the  $\overline{OE}$  input is HIGH, the four three state receiver outputs are in the high-impedance state.

## LOAD TEST CIRCUIT

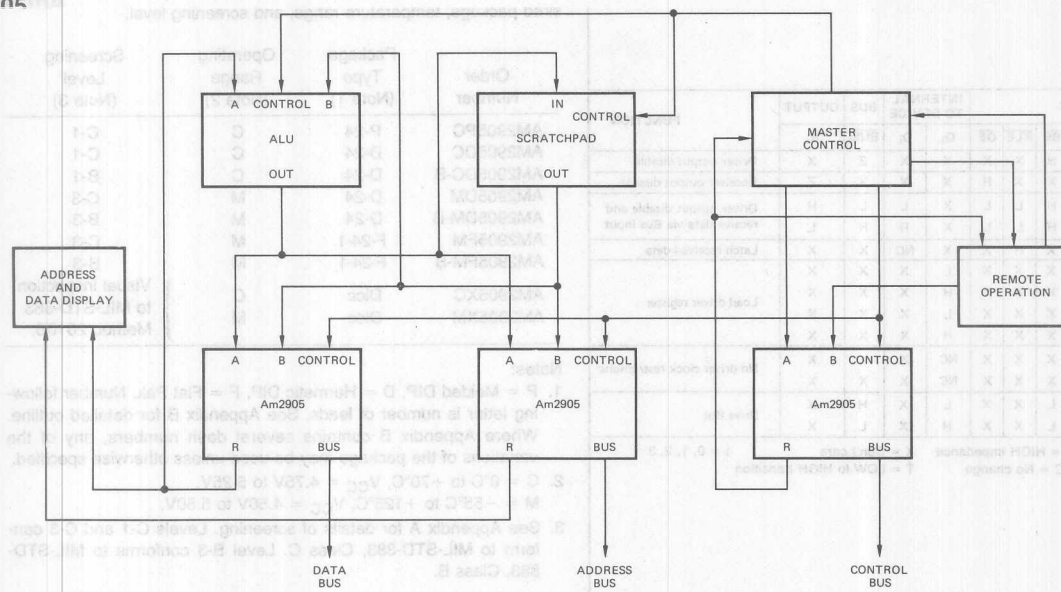


MPR-070

## Metallization and Pad Layout



DIE SIZE 0.080" X 0.130"



The Am2905 is a universal Bus Transceiver useful for many system data, address, control and timing input/output interfaces.

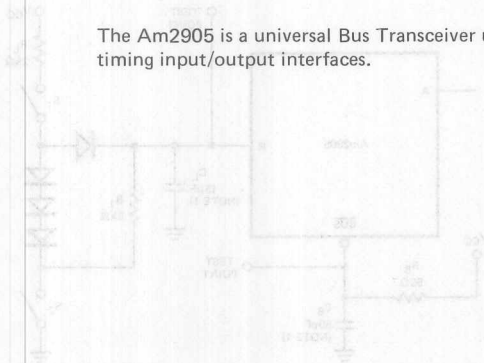
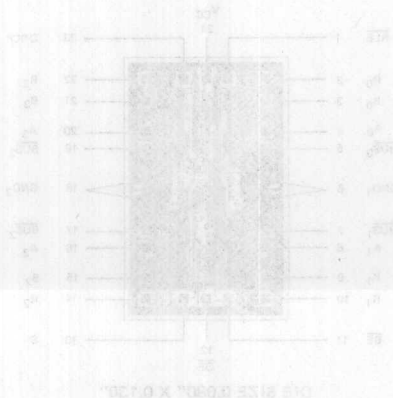


Illustration and Pin Layout



# Am2906

## Quad Two-Input OC Bus Transceiver With Parity

### Distinctive Characteristics

- Quad high-speed LSI bus transceiver.
- Open-collector bus driver.
- Two-port input to D-type register on driver.
- Bus driver output can sink 100 mA at 0.8V max.
- Internal odd 4-bit parity checker/generator.
- Receiver has output latch for pipeline operation.
- Receiver outputs sink 12 mA.
- Advanced low-power Schottky processing.
- 100% reliability assurance testing in compliance with MIL-STD-883.

### FUNCTIONAL DESCRIPTION

The Am2906 is a high-performance, low-power Schottky bus transceiver intended for bipolar or MOS microprocessor system applications. The device consists of four D-type edge-triggered flip-flops with a built-in two-input multiplexer on each. The flip-flop outputs are connected to four open-collector bus drivers. Each bus driver is internally connected to one input of a differential amplifier in the receiver. The four receiver differential amplifier outputs drive four D-type latches. The device also contains a four-bit odd parity checker/generator.

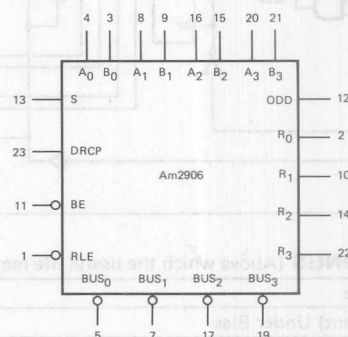
This LSI bus transceiver is fabricated using advanced low-power Schottky processing. All inputs (except the BUS inputs) are one LS unit load. The open-collector bus output can sink up to 100 mA at 0.8V maximum. The BUS input differential amplifier contains disconnect protection diodes such that the bus is fail-safe when power is not applied. The bus enable input ( $\overline{BE}$ ) is used to force the driver outputs to the high-impedance state. When  $\overline{BE}$  is HIGH, the driver is disabled. The open-collector structure of the driver allows wired-OR operations to be performed on the bus.

The input register consists of four D-type flip-flops with a buffered common clock and a two-input multiplexer at the input of each flip-flop. A common select input (S) controls the four multiplexers. When S is LOW, the  $A_i$  data is stored in the register and when S is HIGH, the  $B_i$  data is stored. The buffered common clock (DRCP) enters the data into this driver register on the LOW-to-HIGH transition.

Data from the A or B input is inverted at the BUS output. Likewise, data at the BUS input is inverted at the receiver output. Thus, data is non-inverted from driver input to receiver output. The four receivers each feature a built-in D-type latch that is controlled from the buffered receiver latch enable ( $\overline{RLE}$ ) input. When the  $\overline{RLE}$  input is LOW, the latch is open and the receiver outputs will follow the bus inputs (BUS data inverted). When the  $\overline{RLE}$  input is HIGH, the latch will close and retain the present data regardless of the bus input.

The Am2906 features a built-in four-bit odd parity checker/generator. The bus enable input ( $\overline{BE}$ ) controls whether the parity output is in the generate or check mode. When the bus enable is LOW (driver enabled), odd parity is generated based on the A or B field data input to the driver register. When  $\overline{BE}$  is HIGH, the parity output is determined by the four latch outputs of the receiver. Thus, if the driver is enabled, parity is generated and if the driver is in the high-impedance state, the BUS parity is checked.

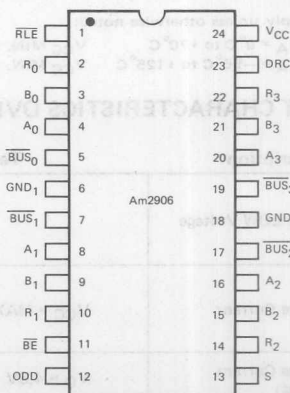
### LOGIC SYMBOL



$V_{CC}$  = Pin 24  
 $GND_1$  = Pin 6  
 $GND_2$  = Pin 18

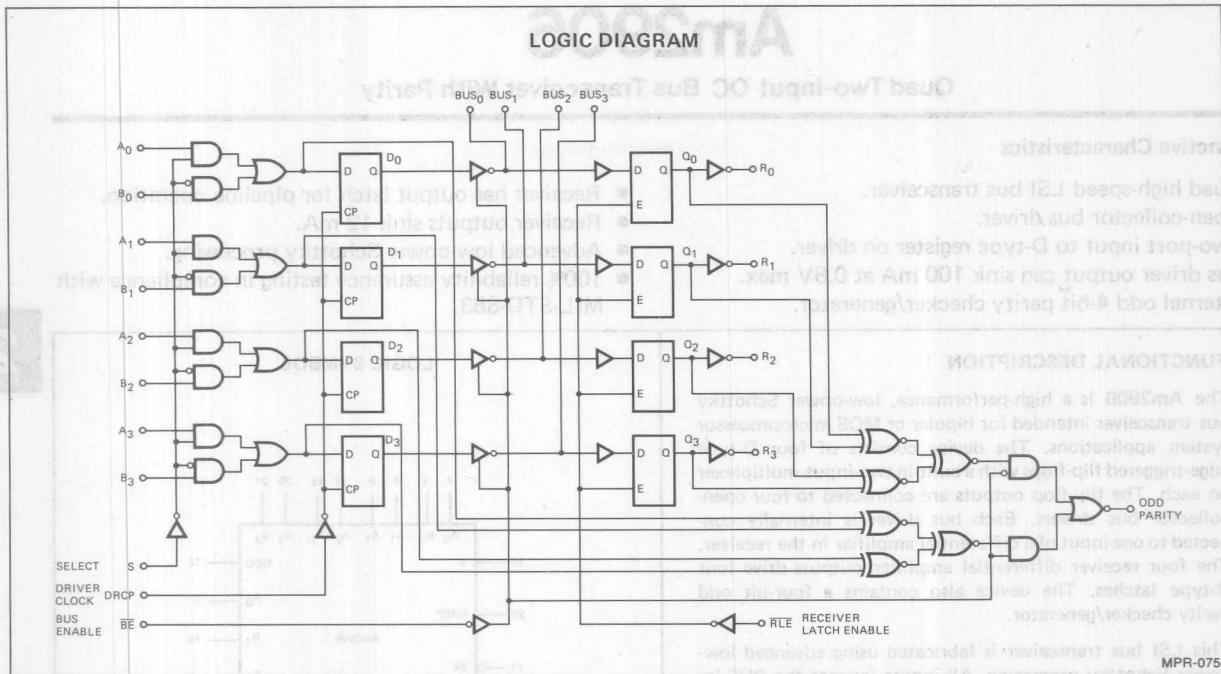
MPR-073

### CONNECTION DIAGRAM Top View



Note: Pin 1 is marked for orientation:

MPR-074



**MAXIMUM RATINGS** (Above which the useful life may be impaired)

|   |                                |
|---|--------------------------------|
| Storage Temperature                                 | -65°C to +150°C                |
| Temperature (Ambient) Under Bias                    | -55°C to +125°C                |
| Supply Voltage to Ground Potential                  | -0.5V to +7V                   |
| DC Voltage Applied to Outputs for HIGH Output State | -0.5V to +V <sub>CC</sub> max. |
| DC Input Voltage                                    | -0.5V to +5.5V                 |
| DC Output Current, Into Outputs (Except Bus)        | 30mA                           |
| DC Output Current, Into Bus                         | 200mA                          |
| DC Input Current                                    | -30mA to +5.0mA                |

**ELECTRICAL CHARACTERISTICS**

The following conditions apply unless otherwise noted:

|                  |                                  |                              |                              |
|------------------|----------------------------------|------------------------------|------------------------------|
| Am2906XC (COM'L) | T <sub>A</sub> = 0°C to +70°C    | V <sub>CC</sub> MIN. = 4.75V | V <sub>CC</sub> MAX. = 5.25V |
| Am2906XM (MIL)   | T <sub>A</sub> = -55°C to +125°C | V <sub>CC</sub> MIN. = 4.50V | V <sub>CC</sub> MAX. = 5.50V |

**BUS INPUT/OUTPUT CHARACTERISTICS OVER OPERATING TEMPERATURE RANGE**

| Parameters       | Description                     | Test Conditions (Note 1)                        | Min.  | Typ.<br>(Note 2) | Max. | Units. |
|------------------|---------------------------------|---|-------|------------------|------|--------|
| V <sub>OL</sub>  | Bus Output LOW Voltage          | I <sub>OL</sub> = 40mA                          |       | 0.32             | 0.5  | Volts  |
|                  |                                 | I <sub>OL</sub> = 70mA                          |       | 0.41             | 0.7  |        |
|                  |                                 | I <sub>OL</sub> = 100mA                         |       | 0.55             | 0.8  |        |
| I <sub>O</sub>   | Bus Leakage Current             | V <sub>CC</sub> = MAX.<br>V <sub>O</sub> = 4.5V |       |                  | -50  | μA     |
|                  |                                 |   | MIL   |                  | 200  |        |
|                  |                                 |   | COM'L |                  | 100  |        |
| I <sub>OFF</sub> | Bus Leakage Current (Power OFF) | V <sub>O</sub> = 4.5V                           |       |                  | 100  | μA     |
| V <sub>TH</sub>  | Receiver Input HIGH Threshold   | Bus enable = 2.4V                               | MIL   | 2.4              | 2.0  | Volts  |
|                  |                                 |   | COM'L | 2.3              | 2.0  |        |
| V <sub>TL</sub>  | Receiver Input LOW Threshold    | Bus enable = 2.4V                               | MIL   |                  | 2.0  | Volts  |
|                  |                                 |   | COM'L |                  | 1.5  |        |



## ELECTRICAL CHARACTERISTICS

The following conditions apply unless otherwise noted:

Am2906XC (COM'L)  $T_A = 0^\circ\text{C to } +70^\circ\text{C}$   $V_{CC} \text{ MIN.} = 4.75\text{V}$   $V_{CC} \text{ MAX.} = 5.25\text{V}$   
 Am2906XM (MIL)  $T_A = -55^\circ\text{C to } +125^\circ\text{C}$   $V_{CC} \text{ MIN.} = 4.5\text{V}$   $V_{CC} \text{ MAX.} = 5.5\text{V}$

## DC CHARACTERISTICS OVER OPERATING TEMPERATURE RANGE

| Parameters | Description                               | Test Conditions (Note 1)   |                        | Min.                     | Typ.<br>(Note 2) | Max.  | Units         |
|------------|---|--|------------------------|--------------------------|------------------|-------|---------------|
| $V_{OH}$   | Receiver Output HIGH Voltage              | $V_{CC} = \text{MIN.}$<br>$V_{IN} = V_{IL} \text{ or } V_{IH}$                           | MIL                    | $I_{OH} = -1\text{mA}$   | 2.4              | 3.4   | Volts         |
|            |   |  | COM'L                  | $I_{OH} = -2.6\text{mA}$ | 2.4              | 3.4   |               |
|            | Parity Output HIGH Voltage                | $V_{CC} = \text{MIN.}, I_{OH} = -660\mu\text{A}$<br>$V_{IN} = V_{IH} \text{ or } V_{IL}$ | MIL                    |                          | 2.5              | 3.4   |               |
|            |   |  | COM'L                  |                          | 2.7              | 3.4   |               |
| $V_{OL}$   | Output LOW Voltage (Except Bus)           | $V_{CC} = \text{MIN.}$<br>$V_{IN} = V_{IL} \text{ or } V_{IH}$                           | $I_{OL} = 4\text{mA}$  |                          | 0.27             | 0.4   | Volts         |
|            |   |  | $I_{OL} = 8\text{mA}$  |                          | 0.32             | 0.45  |               |
|            |   |  | $I_{OL} = 12\text{mA}$ |                          | 0.37             | 0.5   |               |
| $V_{IH}$   | Input HIGH Level (Except Bus)             | Guaranteed input logical HIGH for all inputs   |                        | 2.0                      |                  |       | Volts         |
| $V_{IL}$   | Input LOW Level (Except Bus)              | Guaranteed input logical LOW for all inputs  | MIL                    |                          |                  | 0.7   | Volts         |
|            |   |  | COM'L                  |                          |                  | 0.8   |               |
| $V_I$      | Input Clamp Voltage (Except Bus)          | $V_{CC} = \text{MIN.}, I_{IN} = -18\text{mA}$  |                        |                          |                  | -1.2  | Volts         |
| $I_{IL}$   | Input LOW Current (Except Bus)            | $V_{CC} = \text{MAX.}, V_{IN} = 0.4\text{V}$   |                        |                          |                  | -0.36 | mA            |
| $I_{IH}$   | Input HIGH Current (Except Bus)           | $V_{CC} = \text{MAX.}, V_{IN} = 2.7\text{V}$   |                        |                          |                  | 20    | $\mu\text{A}$ |
| $I_I$      | Input HIGH Current (Except Bus)           | $V_{CC} = \text{MAX.}, V_{IN} = 5.5\text{V}$   |                        |                          |                  | 100   | $\mu\text{A}$ |
| $I_{SC}$   | Output Short Circuit Current (Except Bus) | $V_{CC} = \text{MAX.}$   |                        | -12                      |                  | -65   | mA            |
| $I_{CC}$   | Power Supply Current                      | $V_{CC} = \text{MAX.}, \text{All inputs} = \text{GND}$                                   |                        |                          | 72               | 105   | mA            |

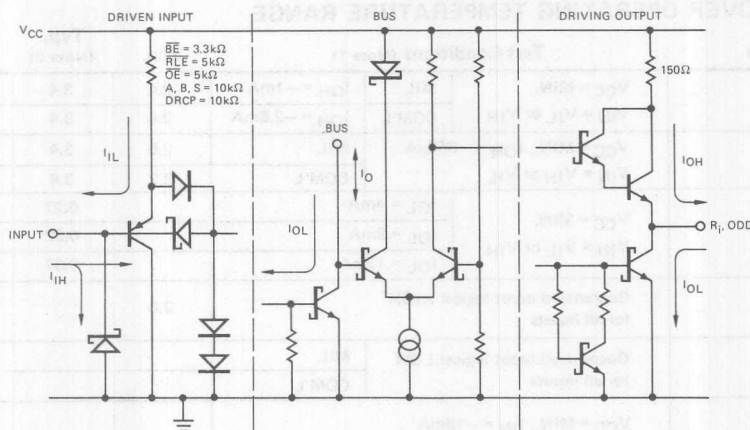
## SWITCHING CHARACTERISTICS OVER OPERATING TEMPERATURE RANGE

|                  |  |   | Am2906XM |          |      | Am2906XC |          |      |       |
|------------------|--|---|----------|----------|------|----------|----------|------|-------|
| Parameters       | Description  | Test Conditions   | Typ.     |          |      | Typ.     |          |      | Units |
|                  |  |   | Min.     | (Note 2) | Max. | Min.     | (Note 2) | Max. |       |
| t <sub>PHL</sub> | Driver Clock (DRCP) to Bus                                       | C <sub>L</sub> (BUS) = 50pF<br>R <sub>L</sub> (BUS) = 50Ω |          | 21       | 40   |          | 21       | 36   | ns    |
| t <sub>PLH</sub> |  |   |          | 21       | 40   |          | 21       | 36   |       |
| t <sub>PHL</sub> | Bus Enable ( $\overline{\text{BE}}$ ) to Bus                     |   |          | 13       | 26   |          | 13       | 23   | ns    |
| t <sub>PLH</sub> |  |   |          | 13       | 26   |          | 13       | 23   |       |
| t <sub>s</sub>   | Data Inputs (A or B)   | C <sub>L</sub> = 15pF<br>R <sub>L</sub> = 2.0kΩ           | 25       |          |      | 23       |          |      | ns    |
| t <sub>h</sub>   |  |   | 8.0      |          |      | 7.0      |          |      |       |
| t <sub>s</sub>   | Select Inputs (S)  |   | 33       |          |      | 30       |          |      | ns    |
| t <sub>h</sub>   |  |   | 8.0      |          |      | 7.0      |          |      |       |
| t <sub>PW</sub>  | Clock Pulse Width (HIGH)   |   | 28       |          |      | 25       |          |      | ns    |
| t <sub>PLH</sub> | Bus to Receiver Output<br>(Latch Enabled)                        |   |          | 18       | 37   |          | 18       | 34   | ns    |
| t <sub>PHL</sub> |  |   |          | 18       | 37   |          | 18       | 34   |       |
| t <sub>PLH</sub> | Latch Enable to Receiver Output                                  |   |          | 21       | 37   |          | 21       | 34   | ns    |
| t <sub>PHL</sub> |  |   |          | 21       | 37   |          | 21       | 34   |       |
| t <sub>s</sub>   | Bus to Latch Enable ( $\overline{\text{RLE}}$ )                  |   | 21       |          |      | 18       |          |      | ns    |
| t <sub>h</sub>   |  |   | 7.0      |          |      | 5.0      |          |      |       |
| t <sub>PLH</sub> | A or B Data to Odd Parity Output<br>(Driver Enabled)             |   |          | 21       | 40   |          | 21       | 36   | ns    |
| t <sub>PHL</sub> |  |   |          | 21       | 40   |          | 21       | 36   |       |
| t <sub>PLH</sub> | Bus to Odd Parity Output<br>(Driver Inhibited, Latch Enabled)    |   |          | 21       | 40   |          | 21       | 36   | ns    |
| t <sub>PHL</sub> |  |   |          | 21       | 40   |          | 21       | 36   |       |
| t <sub>PLH</sub> | Latch Enable ( $\overline{\text{RLE}}$ ) to<br>Odd Parity Output |   |          | 21       | 40   |          | 21       | 36   | ns    |
| t <sub>PHL</sub> |  |   |          | 21       | 40   |          | 21       | 36   |       |

Notes: 1. For conditions shown as MIN. or MAX., use the appropriate value specified under Electrical Characteristics for the applicable device type.

2. Typical limits are at  $V_{CC} = 5.0\text{V}$ ,  $25^\circ\text{C}$  ambient and maximum loading.

3. Not more than one output should be shorted at a time. Duration of the short circuit test should not exceed one second.

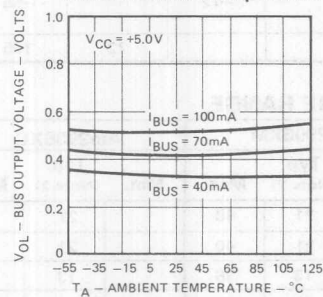


Note: Actual current flow direction shown.

MPR-076

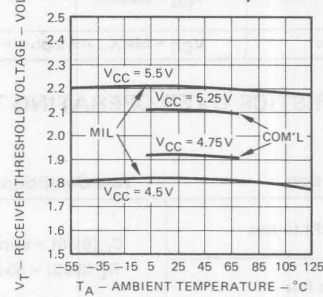
### TYPICAL PERFORMANCE CURVES

Bus Output Low Voltage  
Versus Ambient Temperature



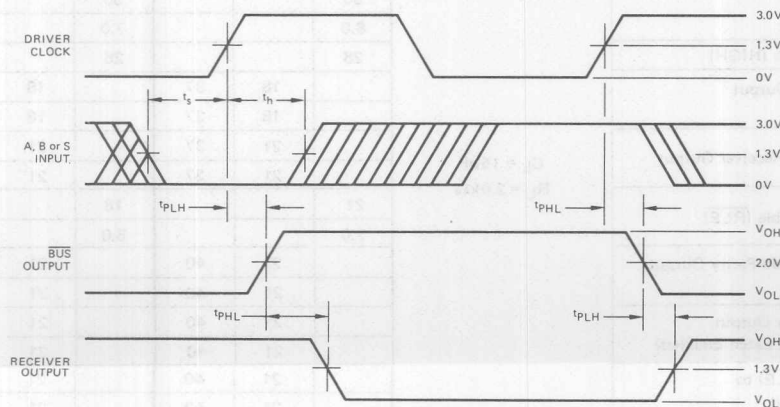
MPR-077

Receiver Threshold Variation  
Versus Ambient Temperature



MPR-078

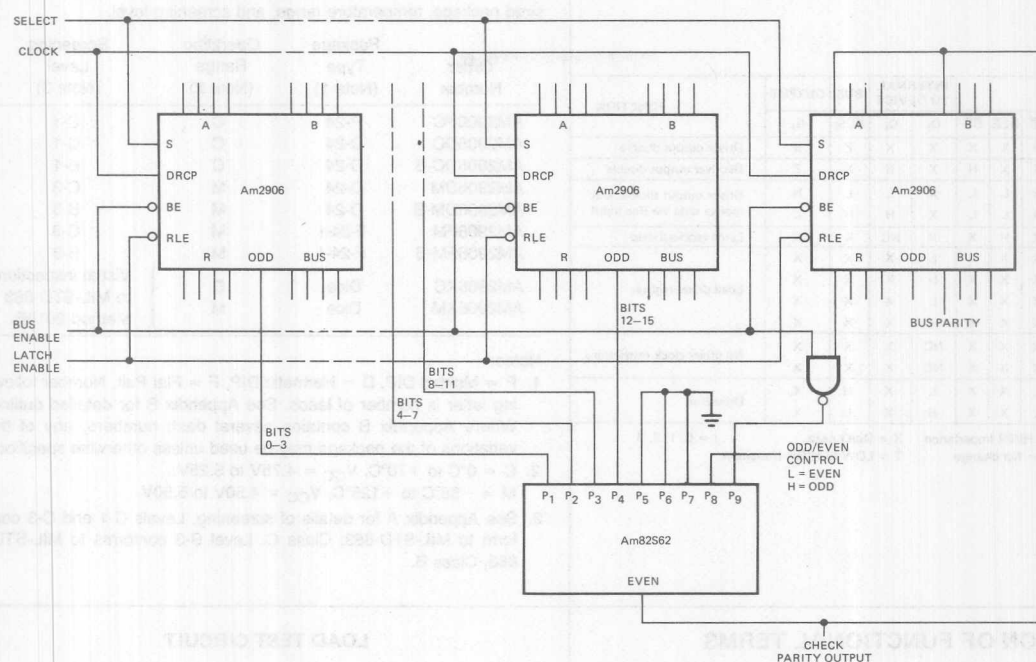
### SWITCHING WAVEFORMS



Note: Bus to Receiver output delay is measured by clocking data into the driver register and measuring the  $\overline{\text{BUS}}$  to R combinatorial delay.

MPR-079

## APPLICATIONS



2

Generating or checking parity for 16 data bits.

MPR-081

## FUNCTION TABLE

| INPUTS |                |                |      |    |     | INTERNAL TO DEVICE |                | BUS            | OUTPUT           | FUNCTION |  |
|--------|----------------|----------------|------|----|-----|--------------------|----------------|----------------|------------------|----------|--|
| S      | A <sub>i</sub> | B <sub>i</sub> | DRCP | BE | RLE | OE                 | D <sub>i</sub> | Q <sub>i</sub> | BUS <sub>i</sub> |          | R <sub>i</sub>                                       |
| X      | X              | X              | X    | H  | X   | X                  | X              | X              | Z                | X        | Driver output disable                                |
| X      | X              | X              | X    | X  | X   | H                  | X              | X              | X                | Z        | Receiver output disable                              |
| X      | X              | X              | X    | H  | L   | L                  | X              | L              | L                | H        | Driver output disable and receive data via Bus input |
| X      | X              | X              | X    | H  | L   | L                  | X              | H              | H                | L        | Latch received data                                  |
| X      | X              | X              | X    | X  | H   | X                  | X              | NC             | X                | X        | Load driver register                                 |
| L      | L              | X              | ↑    | X  | X   | X                  | L              | X              | X                | X        |  |
| L      | H              | X              | ↑    | X  | X   | X                  | H              | X              | X                | X        |  |
| H      | X              | L              | ↑    | X  | X   | X                  | L              | X              | X                | X        |  |
| H      | X              | H              | ↑    | X  | X   | X                  | H              | X              | X                | X        | No driver clock restrictions                         |
| X      | X              | X              | L    | X  | X   | X                  | NC             | X              | X                | X        |  |
| X      | X              | X              | H    | X  | X   | X                  | NC             | X              | X                | X        | Drive Bus  |
| X      | X              | X              | X    | L  | X   | X                  | L              | X              | H                | X        |  |
| X      | X              | X              | X    | L  | X   | X                  | H              | X              | L                | X        |  |

H = HIGH  
L = LOW  
Z = HIGH impedance  
NC = No change  
X = Don't care  
↑ = LOW to HIGH transition  
i = 0, 1, 2, 3

## ORDERING INFORMATION

Order the part number according to the table below to obtain the desired package, temperature range, and screening level.

| Order Number | Package Type (Note 1) | Operating Range (Note 2) | Screening Level (Note 3)                       |
|--------------|-----------------------|--------------------------|--|
| AM2906PC     | P-24                  | C                        | C-1  |
| AM2906DC     | D-24                  | C                        | C-1  |
| AM2906DC-B   | D-24                  | C                        | B-1  |
| AM2906DM     | D-24                  | M                        | C-3  |
| AM2906DM-B   | D-24                  | M                        | B-3  |
| AM2906FM     | F-24-1                | M                        | C-3  |
| AM2906FM-B   | F-24-1                | M                        | B-3  |
| AM2906XC     | Dice                  | C                        | Visual inspection to MIL-STD-883 Method 2010B. |
| AM2906XM     | Dice                  | M                        |  |

## Notes:

1. P = Molded DIP, D = Hermetic DIP, F = Flat Pak. Number following letter is number of leads. See Appendix B for detailed outline. Where Appendix B contains several dash numbers, any of the variations of the package may be used unless otherwise specified.
2. C = 0°C to +70°C, V<sub>CC</sub> = 4.75V to 5.25V.  
M = -55°C to +125°C, V<sub>CC</sub> = 4.50V to 5.50V.
3. See Appendix A for details of screening. Levels C-1 and C-3 conform to MIL-STD-883, Class C. Level B-3 conforms to MIL-STD-883, Class B.

## DEFINITION OF FUNCTIONAL TERMS

A<sub>0</sub>, A<sub>1</sub>, A<sub>2</sub>, A<sub>3</sub> The "A" word data input into the two input multiplexers of the driver register.

B<sub>0</sub>, B<sub>1</sub>, B<sub>2</sub>, B<sub>3</sub> The "B" word data input into the two input multiplexers of the driver register.

S Select. When the select input is LOW, the A data word is applied to the driver register. When the select input is HIGH, the B word is applied to the driver register.

DRCP Driver Clock Pulse. Clock pulse for the driver register.

BE Bus Enable. When the Bus Enable is HIGH, the four drivers are in the high impedance state.

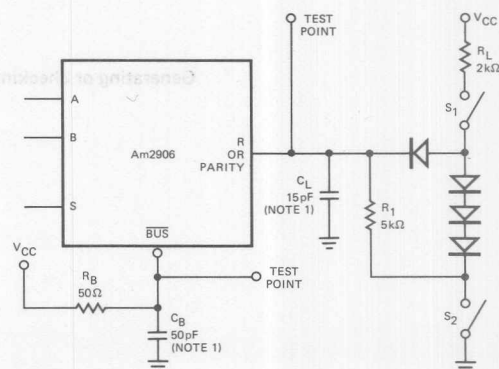
BUS<sub>0</sub>, BUS<sub>1</sub>, BUS<sub>2</sub>, BUS<sub>3</sub> The four driver outputs and receiver inputs (data is inverted).

R<sub>0</sub>, R<sub>1</sub>, R<sub>2</sub>, R<sub>3</sub> The four receiver outputs. Data from the bus is inverted while data from the A or B inputs is non-inverted.

RLE Receiver Latch Enable. When RLE is LOW, data on the BUS inputs is passed through the receiver latches. When RLE is HIGH, the receiver latches are closed and will retain the data independent of all other inputs.

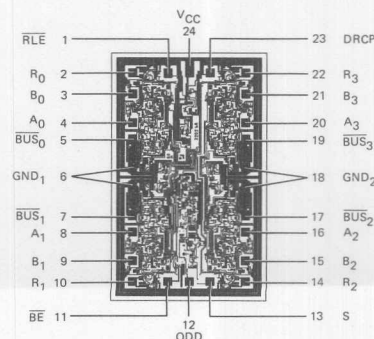
OE Output Enable. When the OE input is HIGH, the four three state receiver outputs are in the high-impedance state.

## LOAD TEST CIRCUIT



MPR-080

## Metallization and Pad Layout



DIE SIZE 0.080" X 0.130"



# Am2907 • Am2908

## Quad Bus Transceivers with Interface Logic

### Distinctive Characteristics

- Quad high-speed LSI bus-transceiver
- Open-collector bus driver
- D-type register on driver
- Bus driver output can sink 100mA at 0.8V max.
- Internal odd 4-bit parity checker/generator

- Am2907 has 2.0V input receiver threshold; Am2908 is "DEC Q or LSI-II bus compatible" with 1.5V receiver threshold
- Receiver has output latch for pipeline operation
- Three-state receiver outputs sink 12mA
- Advanced Low-power Schottky processing
- 100% reliability assurance testing in compliance with MIL-STD-883

### FUNCTIONAL DESCRIPTION

The Am2907 and Am2908 are high-performance bus transceivers intended for bipolar or MOS microprocessor system applications. The Am2908 is Digital Equipment Corporation "Q or LSI-II bus compatible" while the Am2907 features a 2.0V receiver threshold. These devices consist of four D-type edge-triggered flip-flops. The flip-flop outputs are connected to four open-collector bus drivers. Each bus driver is internally connected to one input of a differential amplifier in the receiver. The four receiver differential amplifier outputs drive four D-type latches, that feature three-state outputs. The devices also contain a four-bit odd parity checker/generator.

These LSI bus transceivers are fabricated using advanced low-power Schottky processing. All inputs (except the BUS inputs) are one LS unit load. The open-collector bus output can sink up to 100mA at 0.8V maximum. The BUS input differential amplifier contains disconnect protection diodes such that the bus is fail-safe when power is not applied. The bus enable input ( $\overline{BE}$ ) is used to force the driver outputs to the high-impedance state. When  $\overline{BE}$  is HIGH, the driver is disabled. The open-collector structure of the driver allows wired-OR operations to be performed on the bus.

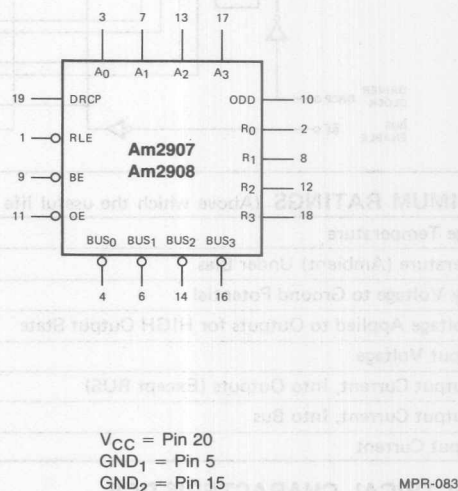
The input register consists of four D-type flip-flops with a buffered common clock. The buffered common clock (DRCP) enters the  $A_i$  data into this driver register on the LOW-to-HIGH transition.

Data from the A input is inverted at the BUS output. Likewise, data at the BUS input is inverted at the receiver output. Thus, data is non-inverted from driver input to receiver output. The four receivers each feature a built-in D-type latch that is controlled from the buffered receiver latch enable ( $\overline{RLE}$ ) input. When the  $\overline{RLE}$  input is LOW, the latch is open and the receiver outputs will follow the bus inputs (BUS data inverted and  $\overline{OE}$  LOW). When the  $\overline{RLE}$  input is HIGH, the latch will close and retain the present data regardless of the bus input. The four latches have three-state outputs and are controlled by a buffered common three-state control ( $\overline{OE}$ ) input. When  $\overline{OE}$  is HIGH, the receiver outputs are in the high-impedance state.

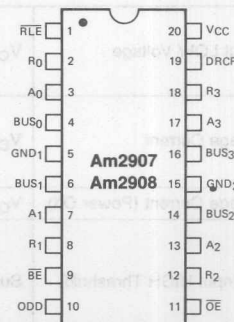
The Am2907 and Am2908 feature a built-in four-bit odd parity checker/generator. The bus enable input ( $\overline{BE}$ ) controls whether the parity output is in the generate or check mode. When the bus enable is LOW (driver enabled), odd parity is generated based on the A field data input to the driver register. When  $\overline{BE}$  is HIGH, the parity output is determined by the four latch outputs of the receiver. Thus, if the driver is enabled, parity is generated and if the driver is in the high-impedance state, the BUS parity is checked.

The Am2907 has receiver threshold typically of 2.0V while the Am2908 threshold is typically 1.5V.

### LOGIC SYMBOL



### CONNECTION DIAGRAM Top View



Note: Pin 1 is marked for orientation.

MPR-084



## ELECTRICAL CHARACTERISTICS

The following conditions apply unless otherwise noted:

Am2907XC, Am2908XC (COM'L)  $T_A = 0^\circ\text{C to } +70^\circ\text{C}$   $V_{CC} \text{ MIN.} = 4.75\text{V}$   $V_{CC} \text{ MAX.} = 5.25\text{V}$   
 Am2907XM, Am2908XM (MIL)  $T_A = -55^\circ\text{C to } +125^\circ\text{C}$   $V_{CC} \text{ MIN.} = 4.50\text{V}$   $V_{CC} \text{ MAX.} = 5.50\text{V}$

## DC CHARACTERISTICS OVER OPERATING TEMPERATURE RANGE

| Parameters | Description                                 | Test Conditions (Note 1)  |  | Min.       | Typ. (Note 2)        | Max.               | Units         |
|------------|---|---|--|------------|----------------------|--------------------|---------------|
| $V_{OH}$   | Receiver Output HIGH Voltage                | $V_{CC} = \text{MIN.}$<br>$V_{IN} = V_{IL} \text{ or } V_{IH}$                              | MIL: $I_{OH} = -1\text{mA}$<br>COM'L: $I_{OH} = -2.6\text{mA}$           | 2.4        | 3.4                  |                    | Volts         |
| $V_{OH}$   | Parity Output HIGH Voltage                  | $V_{CC} = \text{MIN.}$ , $I_{OH} = -660\mu\text{A}$<br>$V_{IN} = V_{IH} \text{ or } V_{IL}$ | MIL<br>COM'L   | 2.5<br>2.7 | 3.4                  |                    | Volts         |
| $V_{OL}$   | Output LOW Voltage (Except Bus)             | $V_{CC} = \text{MIN.}$<br>$V_{IN} = V_{IL} \text{ or } V_{IH}$                              | $I_{OL} = 4\text{mA}$<br>$I_{OL} = 8\text{mA}$<br>$I_{OL} = 12\text{mA}$ |            | 0.27<br>0.32<br>0.37 | 0.4<br>0.45<br>0.5 | Volts         |
| $V_{IH}$   | Input HIGH Level (Except Bus)               | Guaranteed input logical HIGH for all inputs  |  | 2.0        |                      |                    | Volts         |
| $V_{IL}$   | Input LOW Level (Except Bus)                | Guaranteed input logical LOW for all inputs   |  |            |                      | 0.7<br>0.8         | Volts         |
| $V_I$      | Input Clamp Voltage (Except Bus)            | $V_{CC} = \text{MIN.}$ , $I_{IN} = -18\text{mA}$  |  |            |                      | -1.2               | Volts         |
| $I_{IL}$   | Input LOW Current (Except Bus)              | $V_{CC} = \text{MAX.}$ , $V_{IN} = 0.4\text{V}$   |  |            |                      | -0.36              | mA            |
| $I_{IH}$   | Input HIGH Current (Except Bus)             | $V_{CC} = \text{MAX.}$ , $V_{IN} = 2.7\text{V}$   |  |            |                      | 20                 | $\mu\text{A}$ |
| $I_I$      | Input HIGH Current (Except Bus)             | $V_{CC} = \text{MAX.}$ , $V_{IN} = 5.5\text{V}$   |  |            |                      | 100                | $\mu\text{A}$ |
| $I_{SC}$   | Output Short Circuit Current (Except Bus)   | $V_{CC} = \text{MAX.}$  |  | -12        |                      | -65                | mA            |
| $I_{CC}$   | Power Supply Current                        | $V_{CC} = \text{MAX.}$ , All Inputs = GND   |  |            | 75                   | 110                | mA            |
| $I_O$      | Off-State Output Current (Receiver Outputs) | $V_{CC} = \text{MAX.}$  | $V_O = 2.4\text{V}$<br>$V_O = 0.4\text{V}$                               |            |                      | 20<br>-20          | $\mu\text{A}$ |

## Am2907 SWITCHING CHARACTERISTICS OVER OPERATING TEMPERATURE RANGE

| Am2907/7XM CHARACTERISTICS       |  |   |          |                  |      |          |                  |      |       |
|----------------------------------|--|---|----------|------------------|------|----------|------------------|------|-------|
| OVER OPERATING TEMPERATURE RANGE |  |   |          |                  |      |          |                  |      |       |
| Parameters                       | Description  | Test Conditions   | Am2907XM |                  |      | Am2907XC |                  |      | Units |
|                                  |  |   | Min.     | Typ.<br>(Note 2) | Max. | Min.     | Typ.<br>(Note 2) | Max. |       |
| t <sub>PHL</sub>                 | Driver Clock (DRCP) to Bus                                       | C <sub>L</sub> (BUS) = 50pF<br>R <sub>L</sub> (BUS) = 50Ω |          | 21               | 40   |          | 21               | 36   | ns    |
| t <sub>PLH</sub>                 |  |   |          | 21               | 40   |          | 21               | 36   |       |
| t <sub>PHL</sub>                 | Bus Enable ( $\overline{\text{BE}}$ ) to Bus                     |   |          | 13               | 26   |          | 13               | 23   | ns    |
| t <sub>PLH</sub>                 |  |   |          | 13               | 26   |          | 13               | 23   |       |
| t <sub>s</sub>                   | Data Inputs  | C <sub>L</sub> = 15pF<br>R <sub>L</sub> = 2.0kΩ           | 18       |                  |      | 15       |                  |      | ns    |
| t <sub>h</sub>                   |  |   | 8.0      |                  |      | 7.0      |                  |      |       |
| t <sub>PW</sub>                  | Clock Pulse Width (HIGH)   |   | 28       |                  |      | 25       |                  |      | ns    |
| t <sub>PLH</sub>                 | Bus to Receiver Output<br>(Latch Enabled)                        |   | 18       | 37               |      | 18       | 34               | ns   |       |
| t <sub>PHL</sub>                 |  |   | 18       | 37               |      | 18       | 34               |      |       |
| t <sub>PLH</sub>                 | Latch Enable to Receiver Output                                  |   | 21       | 37               |      | 21       | 34               | ns   |       |
| t <sub>PHL</sub>                 |  |   | 21       | 37               |      | 21       | 34               |      |       |
| t <sub>s</sub>                   | Bus to Latch Enable ( $\overline{\text{RLE}}$ )                  |   | 21       |                  |      | 18       |                  | ns   |       |
| t <sub>h</sub>                   |  |   | 7.0      |                  |      | 5.0      |                  |      |       |
| t <sub>PLH</sub>                 | Data to Odd Parity Out<br>(Driver Enabled)                       |   | 21       | 40               |      | 21       | 36               | ns   |       |
| t <sub>PHL</sub>                 |  |   | 21       | 40               |      | 21       | 36               |      |       |
| t <sub>PLH</sub>                 | Bus to Odd Parity Out<br>(Driver Inhibit)                        |   | 21       | 40               |      | 21       | 36               | ns   |       |
| t <sub>PHL</sub>                 |  |   | 21       | 40               |      | 21       | 36               |      |       |
| t <sub>PLH</sub>                 | Latch Enable ( $\overline{\text{RLE}}$ ) to Odd<br>Parity Output |   | 21       | 40               |      | 21       | 36               | ns   |       |
| t <sub>PHL</sub>                 |  |   | 21       | 40               |      | 21       | 36               |      |       |
| t <sub>ZH</sub>                  | Output Control to Output   |   | 14       | 28               |      | 14       | 25               | ns   |       |
| t <sub>ZL</sub>                  |  |   | 14       | 28               |      | 14       | 25               |      |       |
| t <sub>HZ</sub>                  | Output Control to Output   |   | 14       | 28               |      | 14       | 25               | ns   |       |
| t <sub>LZ</sub>                  |  |   | 14       | 28               |      | 14       | 25               |      |       |

Notes: 1. For conditions shown as MIN. or MAX., use the appropriate value specified under Electrical Characteristics for the applicable device type.

2. Typical limits are at  $V_{CC} = 5.0\text{V}$ ,  $25^\circ\text{C}$  ambient and maximum loading.

3. Not more than one output should be shorted at a time. Duration of the short circuit test should not exceed one second.

# Am2908 SWITCHING CHARACTERISTICS OVER OPERATING TEMPERATURE RANGE

| Am2908           |  |  | Am2908XM |                  |      | Am2908XC |                  |      |       |
|------------------|--|--|----------|------------------|------|----------|------------------|------|-------|
| Parameters       | Description  | Test Conditions  | Min.     | Typ.<br>(Note 2) | Max. | Min.     | Typ.<br>(Note 2) | Max. | Units |
| t <sub>PHL</sub> | Driver Clock (DRCP) to Bus                             | C <sub>L</sub> (BUS) = 50pF<br>R <sub>L</sub> (BUS): 91Ω to V <sub>CC</sub><br>200Ω to GND |          | 21               | 40   |          | 21               | 36   | ns    |
| t <sub>PLH</sub> |  |  |          | 21               | 40   |          | 21               | 36   |       |
| t <sub>PHL</sub> | Bus Enable ( $\overline{BE}$ ) to Bus                  |  |          | 13               | 26   |          | 13               | 23   | ns    |
| t <sub>PLH</sub> |  |  |          | 13               | 26   |          | 13               | 23   |       |
| t <sub>r</sub>   | Bus Output Rise Time                                   |  |          | 5                | 10   |          | 7                | 10   | ns    |
| t <sub>f</sub>   | Bus Output Fall Time                                   |  |          | 3                | 6    |          | 4                | 6    |       |
| t <sub>s</sub>   | Data Inputs  | C <sub>L</sub> = 50pF<br>R <sub>L</sub> = 2.0kΩ  | 18       |                  |      | 15       |                  |      | ns    |
| t <sub>h</sub>   |  |  | 8.0      |                  |      | 7.0      |                  |      |       |
| t <sub>PW</sub>  | Clock Pulse Width (HIGH)                               |  | 28       |                  |      | 25       |                  |      | ns    |
| t <sub>PLH</sub> | Bus to Receiver Output (Latch Enabled)                 |  |          | 18               | 38   |          | 18               | 35   | ns    |
| t <sub>PHL</sub> |  |  |          | 18               | 38   |          | 18               | 35   |       |
| t <sub>PLH</sub> | Latch Enable to Receiver Output                        |  |          | 21               | 38   |          | 21               | 35   | ns    |
| t <sub>PHL</sub> |  |  |          | 21               | 38   |          | 21               | 35   |       |
| t <sub>s</sub>   | Bus to Latch Enable ( $\overline{RLE}$ )               | C <sub>L</sub> = 15pF<br>R <sub>L</sub> = 2.0kΩ  | 21       |                  |      | 18       |                  |      | ns    |
| t <sub>h</sub>   |  |  | 7.0      |                  |      | 5.0      |                  |      |       |
| t <sub>PLH</sub> | Data to Odd Parity Out (Driver Enabled)                |  |          | 21               | 40   |          | 21               | 36   | ns    |
| t <sub>PHL</sub> |  |  |          | 21               | 40   |          | 21               | 36   |       |
| t <sub>PLH</sub> | Bus to Odd Parity Out (Driver Inhibit)                 |  |          | 21               | 40   |          | 21               | 36   | ns    |
| t <sub>PHL</sub> |  |  |          | 21               | 40   |          | 21               | 36   |       |
| t <sub>PLH</sub> | Latch Enable ( $\overline{RLE}$ ) to Odd Parity Output |  |          | 21               | 40   |          | 21               | 36   | ns    |
| t <sub>PHL</sub> |  |  |          | 21               | 40   |          | 21               | 36   |       |
| t <sub>ZH</sub>  | Output Control to Output                               | C <sub>L</sub> = 5.0pF<br>R <sub>L</sub> = 2.0kΩ   |          | 14               | 28   |          | 14               | 25   | ns    |
| t <sub>ZL</sub>  |  |  |          | 14               | 28   |          | 14               | 25   |       |
| t <sub>HZ</sub>  | Output Control to Output                               |  |          | 14               | 28   |          | 14               | 25   | ns    |
| t <sub>LZ</sub>  |  |  |          | 14               | 28   |          | 14               | 25   |       |

Notes: 1. For conditions shown as MIN. or MAX., use the appropriate value specified under Electrical Characteristics for the applicable device type.  
2. Typical limits are at V<sub>CC</sub> = 5.0V, 25°C ambient and maximum loading.

## ORDERING INFORMATION

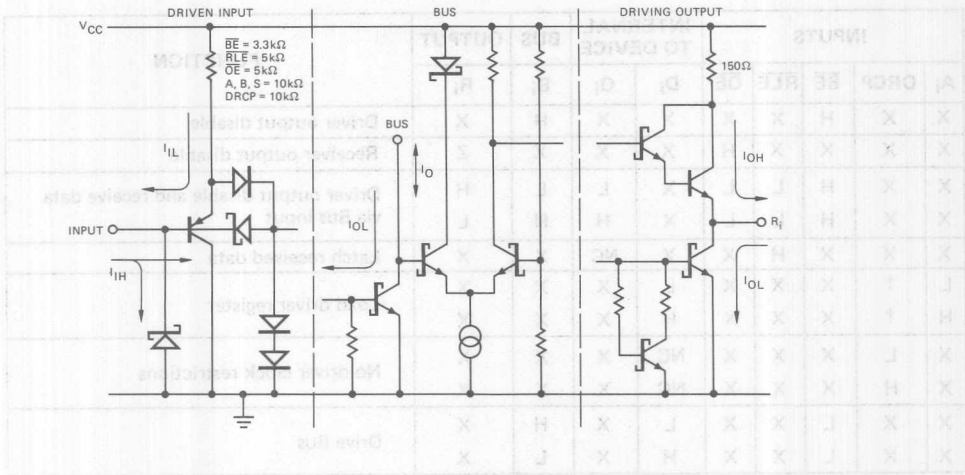
Order the part number according to the table below to obtain the desired package, temperature range, and screening level.

| Am2907<br>Order Number | Am2908<br>Order Number | Package Type<br>(Note 1) | Operating Range<br>(Note 2) | Screening Level<br>(Note 3)                          |
|------------------------|------------------------|--------------------------|-----------------------------|--|
| AM2907PC               | AM2908PC               | P-20                     | C                           | C-1  |
| AM2907DC               | AM2908DC               | D-20                     | C                           | C-1  |
| AM2907DC-B             | AM2908DC-B             | D-20                     | C                           | B-1  |
| AM2907DM               | AM2908DM               | D-20                     | M                           | C-3  |
| AM2907DM-B             | AM2908DM-B             | D-20                     | M                           | B-3  |
| AM2907FM               | AM2908FM               | F-20                     | M                           | C-3  |
| AM2907FM-B             | AM2908FM-B             | F-20                     | M                           | B-3  |
| AM2907XC               | AM2908XC               | Dice                     | C                           | Visual inspection<br>to MIL-STD-883<br>Method 2010B. |
| AM2907XM               | AM2908XM               | Dice                     | M                           |  |

Notes: 1. P = Molded DIP, D = Hermetic DIP, F = Flat Pak. Number following letter is number of leads. See Appendix B for detailed outline.  
Where Appendix B contains several dash numbers, any of the variations of the package may be used unless otherwise specified.  
2. C = 0°C to +70°C, V<sub>CC</sub> = 4.75V to 5.25V, M = -55°C to +125°C, V<sub>CC</sub> = 4.50V to 5.50V.  
3. See Appendix A for details of screening. Levels C-1 and C-3 conform to MIL-STD-883, Class C, Level B-3 conforms to MIL-STD-883, Class B.



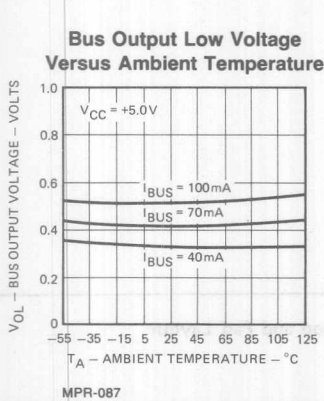
INPUT/OUTPUT CURRENT  
INTERFACE CONDITIONS



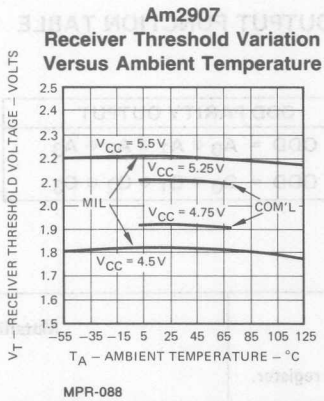
Note: Actual current flow direction shown.

MPR-086

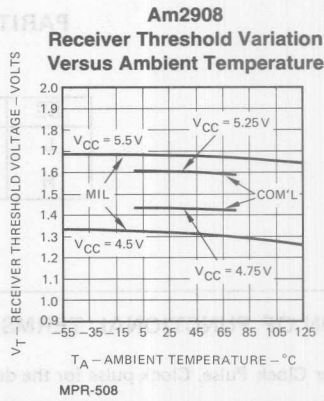
TYPICAL PERFORMANCE CURVES



MPR-087

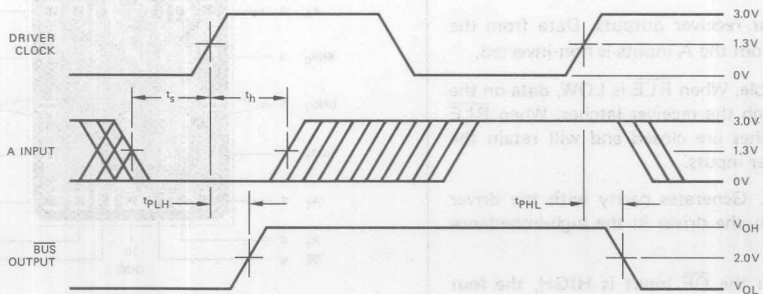


MPR-088



MPR-508

Am2907/08 SWITCHING WAVEFORMS



1. INPUT SET-UP AND HOLD TIMES.

MPR-089

TRUTH TABLE

| INPUTS         |      |                 |                  |                 | INTERNAL TO DEVICE |                | BUS            | OUTPUT         | FUNCTION   |
|----------------|------|-----------------|------------------|-----------------|--------------------|----------------|----------------|----------------|--|
| A <sub>i</sub> | DRCP | $\overline{B}E$ | $\overline{R}LE$ | $\overline{O}E$ | D <sub>i</sub>     | Q <sub>i</sub> | B <sub>i</sub> | R <sub>i</sub> |  |
| X              | X    | H               | X                | X               | X                  | X              | H              | X              | Driver output disable                                |
| X              | X    | X               | X                | H               | X                  | X              | X              | Z              | Receiver output disable                              |
| X              | X    | H               | L                | L               | X                  | L              | L              | H              | Driver output disable and receive data via Bus input |
| X              | X    | H               | L                | L               | X                  | H              | H              | L              |  |
| X              | X    | X               | H                | X               | X                  | NC             | X              | X              | Latch received data                                  |
| L              | ↑    | X               | X                | X               | L                  | X              | X              | X              | Load driver register                                 |
| H              | ↑    | X               | X                | X               | H                  | X              | X              | X              |  |
| X              | L    | X               | X                | X               | NC                 | X              | X              | X              | No driver clock restrictions                         |
| X              | H    | X               | X                | X               | NC                 | X              | X              | X              |  |
| X              | X    | L               | X                | X               | L                  | X              | H              | X              | Drive Bus  |
| X              | X    | L               | X                | X               | H                  | X              | L              | X              |  |

H = HIGH      Z = High Impedance      X = Don't Care      i = 0, 1, 2, 3  
L = LOW      NC = No Change      ↑ = LOW-to-HIGH Transition

PARITY OUTPUT FUNCTION TABLE

| $\overline{B}E$ | ODD PARITY OUTPUT                            |
|-----------------|--|
| L               | $ODD = A_0 \oplus A_1 \oplus A_2 \oplus A_3$ |
| H               | $ODD = Q_0 \oplus Q_1 \oplus Q_2 \oplus Q_3$ |

DEFINITION OF FUNCTIONAL TERMS

**DRCP** Driver Clock Pulse. Clock pulse for the driver register.

**$\overline{B}E$**  Bus Enable. When the Bus Enable is HIGH, the four drivers are in the high impedance state.

**BUS<sub>0</sub>, BUS<sub>1</sub>, BUS<sub>2</sub>, BUS<sub>3</sub>** The four driver outputs and receiver inputs (data is inverted).

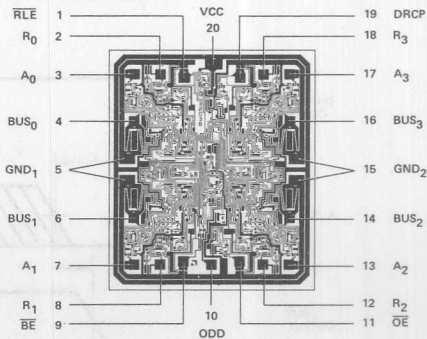
**R<sub>0</sub>, R<sub>1</sub>, R<sub>2</sub>, R<sub>3</sub>** The four receiver outputs. Data from the bus is inverted while data from the A inputs is non-inverted.

**$\overline{R}LE$**  Receiver Latch Enable. When  $\overline{R}LE$  is LOW, data on the BUS inputs is passed through the receiver latches. When  $\overline{R}LE$  is HIGH, the receiver latches are closed and will retain the data independent of all other inputs.

**ODD** Odd parity output. Generates parity with the driver enabled, checks parity with the driver in the high-impedance state.

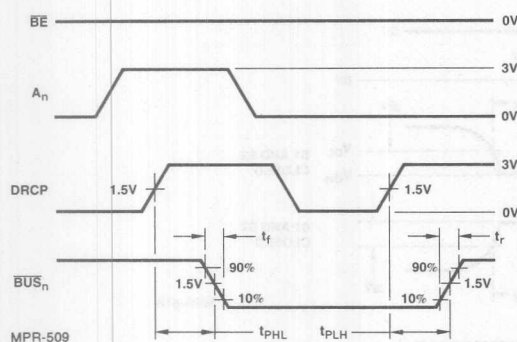
**$\overline{O}E$**  Output Enable. When the  $\overline{O}E$  input is HIGH, the four three-state receiver outputs are in the high-impedance state.

Metallization and Pad Layout

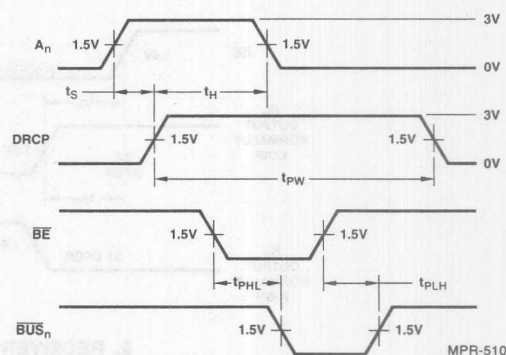


DIE SIZE 0.088" X 0.103"

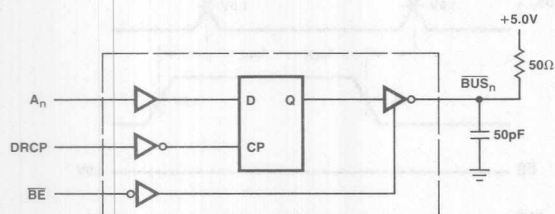
## Am2907/08 SWITCHING WAVEFORMS AND LOAD TEST CIRCUITS



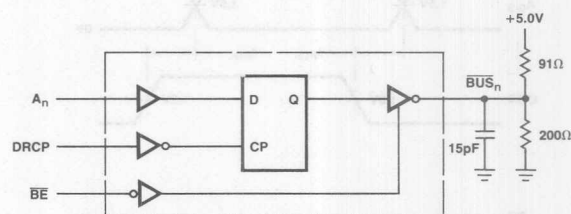
2. DRIVER CLOCK (DRCP) TO BUS

3. BUS ENABLE ( $\overline{BE}$ ) TO BUS

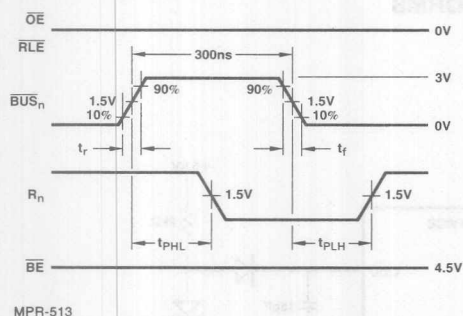
### DRIVER SWITCHING WAVEFORMS



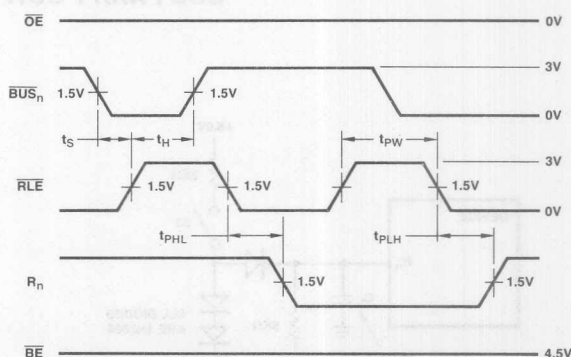
MPR-511

Am2907  
DRIVER LOAD TEST CIRCUIT

MPR-512

Am2908  
DRIVER LOAD TEST CIRCUIT

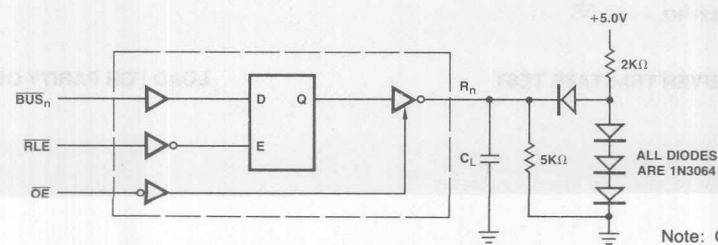
MPR-513

4. BUS TO RECEIVER OUTPUT  
(LATCH ENABLED)

MPR-514

5. LATCH ENABLE TO OUTPUT

### RECEIVER SWITCHING WAVEFORMS

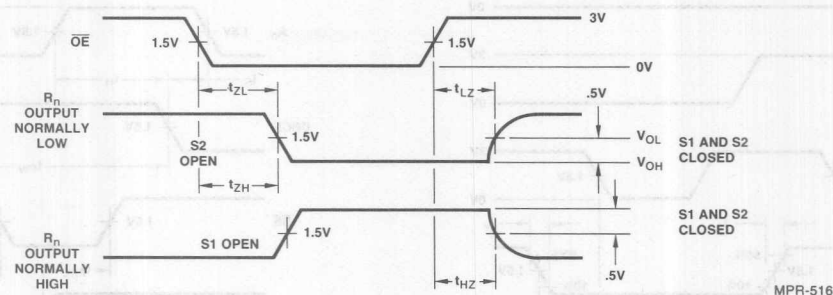


MPR-515

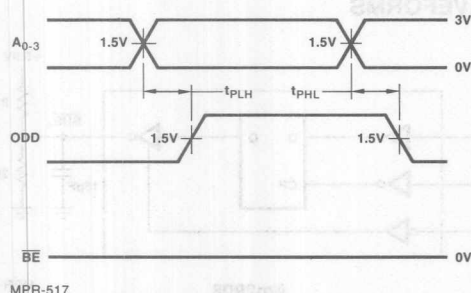
Am2907/08 RECEIVER LOAD TEST CIRCUIT.

Note:  $C_L = 15\text{pF}$  for Am2907  
 $C_L = 50\text{pF}$  for Am2908

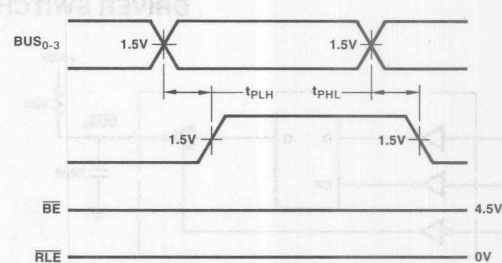
### Am2907/08 SWITCHING WAVEFORMS AND LOAD TEST CIRCUITS (Cont.)



#### 6. RECEIVER TRI-STATE WAVEFORMS

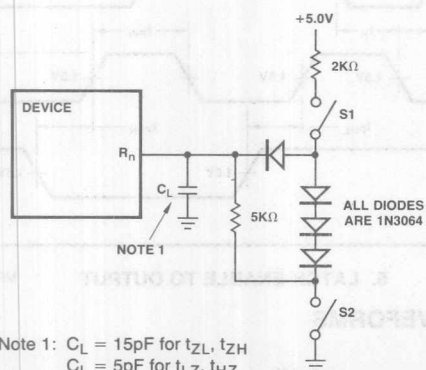


#### 7. A INPUT TO PARITY OUTPUT

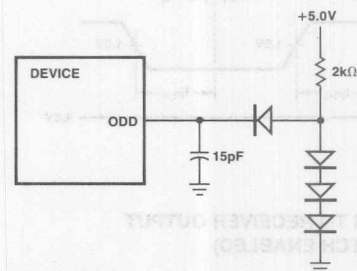


#### 8. BUS TO PARITY OUTPUT

### ODD PARITY OUTPUT WAVEFORMS



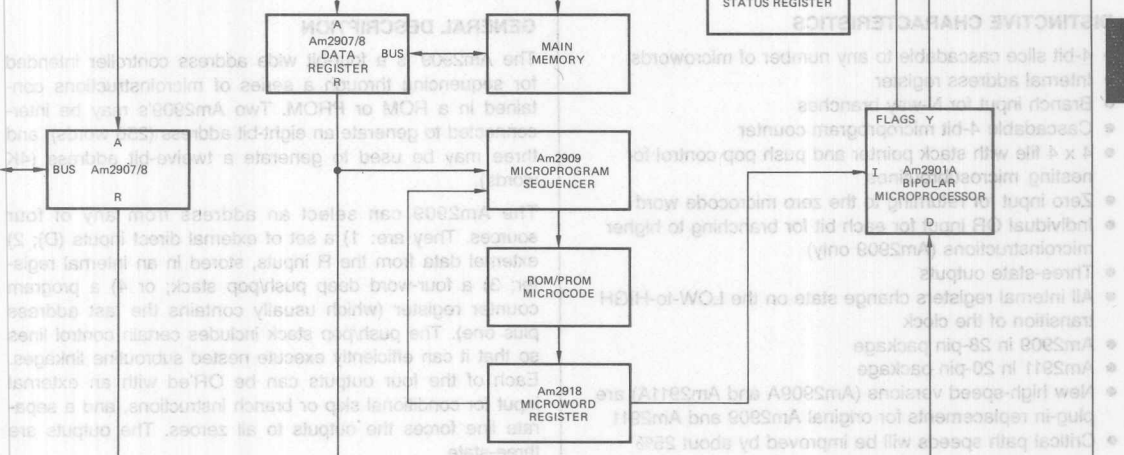
#### LOAD FOR RECEIVER TRI-STATE TEST



#### LOAD FOR PARITY OUTPUT



## 2



The Am2907 can be used as an I/O Bus Transceiver and Main Memory I/O Transceiver in high-speed Microprocessor Systems.

# Am2909 • Am2911

## Am2909A • Am2911A

### Microprogram Sequencers

#### DISTINCTIVE CHARACTERISTICS

- 4-bit slice cascadable to any number of microwords
- Internal address register
- Branch input for N-way branches
- Cascadable 4-bit microprogram counter
- 4 x 4 file with stack pointer and push/pop control for nesting microsubroutines
- Zero input for returning to the zero microcode word
- Individual OR input for each bit for branching to higher microinstructions (Am2909 only)
- Three-state outputs
- All internal registers change state on the LOW-to-HIGH transition of the clock
- Am2909 in 28-pin package
- Am2911 in 20-pin package
- New high-speed versions (Am2909A and Am2911A) are plug-in replacements for original Am2909 and Am2911
- Critical path speeds will be improved by about 25%

#### GENERAL DESCRIPTION

The Am2909 is a four-bit wide address controller intended for sequencing through a series of microinstructions contained in a ROM or PROM. Two Am2909's may be interconnected to generate an eight-bit address (256 words), and three may be used to generate a twelve-bit address (4K words).

The Am2909 can select an address from any of four sources. They are: 1) a set of external direct inputs (D); 2) external data from the R inputs, stored in an internal register; 3) a four-word deep push/pop stack; or 4) a program counter register (which usually contains the last address plus one). The push/pop stack includes certain control lines so that it can efficiently execute nested subroutine linkages. Each of the four outputs can be OR'ed with an external input for conditional skip or branch instructions, and a separate line forces the outputs to all zeroes. The outputs are three-state.

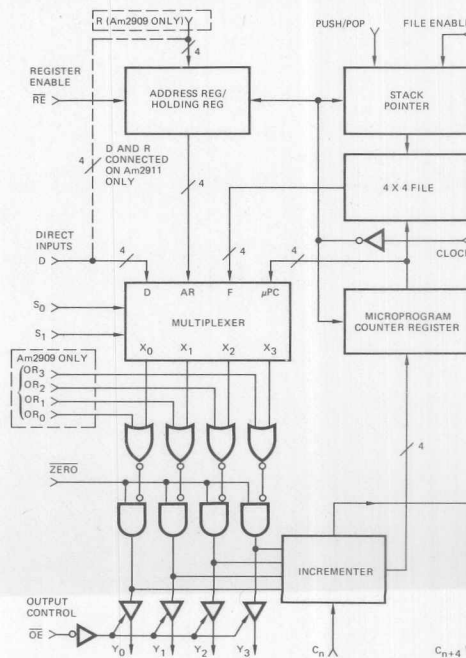
The Am2911 is an identical circuit to the Am2909, except the four OR inputs are removed and the D and R inputs are tied together. The Am2911 is in a 20-pin, 0.3" centers package. The Am2909A and Am2911A are direct plug-in replacements for the Am2909 and Am2911, but are about 25% faster.

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For applications information, see Chapter II of "Build a Microcomputer".

#### MICROPROGRAM SEQUENCER BLOCK DIAGRAM



MPR-093

**MAXIMUM RATINGS** (Above which the useful life may be impaired)

|   |                                 |
|---|---------------------------------|
| Storage Temperature                                 | –65°C to +150°C                 |
| Temperature (Ambient) Under Bias                    | –55°C to +125°C                 |
| Supply Voltage to Ground Potential                  | –0.5 V to +7.0 V                |
| DC Voltage Applied to Outputs for HIGH Output State | –0.5 V to +V <sub>CC</sub> max. |
| DC Input Voltage                                    | –0.5 V to +7.0 V                |
| DC Output Current, Into Outputs                     | 30 mA                           |
| DC Input Current                                    | –30 mA to +5.0 mA               |

**OPERATING RANGE**

| Operating Range | Part Number Suffix | Power Supply | Temperature Range                |
|-----------------|--------------------|--------------|----------------------------------|
| Commercial      | PC, DC             | 5.0V ±5%     | T <sub>A</sub> = 0°C to +70°C    |
| Military        | DM, FM             | 5.0V ±10%    | T <sub>C</sub> = –55°C to +125°C |

**ELECTRICAL CHARACTERISTICS OVER OPERATING RANGE** (Unless Otherwise Notes)

(For Am2909, Am2911, Am2909A, Am2911A)

| Parameters       | Description                              | Test Conditions (Note 1)  | Min.   | Typ.<br>(Note 2) | Max.                      | Units |
|------------------|--|---|--|------------------|---------------------------|-------|
| V <sub>OH</sub>  | Output HIGH Voltage                      | V <sub>CC</sub> = MIN.,<br>V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub> | MIL<br>I <sub>OH</sub> = –1.0mA<br>COM'L<br>I <sub>OH</sub> = –2.6mA   | 2.4              |                           | Volts |
| V <sub>OL</sub>  | Output LOW Voltage                       | V <sub>CC</sub> = MIN.,<br>V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub> | I <sub>OL</sub> = 4.0mA, 2909/11<br>I <sub>OL</sub> = 8.0mA, 2909/11<br>I <sub>OL</sub> = 12mA, 2909/11<br>(Note 5)<br>I <sub>OL</sub> = 16mA, 2909A/11A |                  | 0.4<br>0.45<br>0.5<br>0.5 | Volts |
| V <sub>IH</sub>  | Input HIGH Level                         | Guaranteed input logical HIGH voltage for all inputs                            |  | 2.0              |                           | Volts |
| V <sub>IL</sub>  | Input LOW Level                          | Guaranteed input logical LOW voltage for all inputs                             | MIL, 2909/11<br>All others   |                  | 0.7<br>0.8                | Volts |
| V <sub>I</sub>   | Input Clamp Voltage                      | V <sub>CC</sub> = MIN., I <sub>IN</sub> = –18mA                                 |  |                  | –1.5                      | Volts |
| I <sub>IL</sub>  | Input LOW Current                        | V <sub>CC</sub> = MAX.,<br>V <sub>IN</sub> = 0.4V                               | C <sub>n</sub><br>Push/Pop, $\overline{OE}$<br>Others (Note 6)   |                  | –1.08<br>–0.72<br>–0.36   | mA    |
| I <sub>IH</sub>  | Input HIGH Current                       | V <sub>CC</sub> = MAX.,<br>V <sub>IN</sub> = 2.7V                               | C <sub>n</sub><br>Push/Pop<br>Others (Note 6)  |                  | 40<br>40<br>20            | μA    |
| I <sub>I</sub>   | Input HIGH Current                       | V <sub>CC</sub> = MAX.,<br>V <sub>IN</sub> = 7.0V                               | C <sub>n</sub> , Push/Pop<br>Others (Note 6)   |                  | 0.2<br>0.1                | mA    |
| I <sub>OS</sub>  | Output Short Circuit Current<br>(Note 3) | V <sub>CC</sub> = MAX.  | Y <sub>0</sub> – Y <sub>3</sub><br>C <sub>n</sub> + 4  | –30<br>–30       | –100<br>–85               | mA    |
| I <sub>CC</sub>  | Power Supply Current                     | V <sub>CC</sub> = MAX. (Note 4)   |  | 80               | 130                       | mA    |
| I <sub>OZL</sub> | Output OFF Current                       | V <sub>CC</sub> = MAX.,<br>OE = 2.7V  | V <sub>OUT</sub> = 0.4V  |                  | –20                       | μA    |
| I <sub>OZH</sub> |  |   | V <sub>OUT</sub> = 2.7V  |                  | 20                        |       |

- Notes: 1. For conditions shown as MIN. or MAX., use the appropriate value specified under Electrical Characteristics for the applicable device type.  
 2. Typical limits are at V<sub>CC</sub> = 5.0V, 25°C ambient and maximum loading.  
 3. Not more than one output should be shorted at a time. Duration of the short circuit test should not exceed one second.  
 4. Apply GND to C<sub>n</sub>, R<sub>0</sub>, R<sub>1</sub>, R<sub>2</sub>, R<sub>3</sub>, OR<sub>0</sub>, OR<sub>1</sub>, OR<sub>2</sub>, OR<sub>3</sub>, D<sub>0</sub>, D<sub>1</sub>, D<sub>2</sub>, and D<sub>3</sub>. Other inputs high. All outputs open. Measured after a LOW to HIGH clock transition.  
 5. The 12mA guarantee applies only to Y<sub>0</sub>, Y<sub>1</sub>, Y<sub>2</sub> and Y<sub>3</sub>.  
 6. For the Am2911 and Am2911A, D<sub>i</sub> and R<sub>i</sub> are internally connected. Loading is doubled (to same values as Push/Pop).

# Am2909 and Am2911 SWITCHING CHARACTERISTICS OVER OPERATING RANGE

Tables I, II, and III below define the timing characteristics of the Am2909 and Am2911 over the operating voltage and temperature range. The tables are divided into three types of parameters; clock characteristics, combinational delays from inputs to outputs, and set-up and hold time requirements. The latter table defines the time prior to the end of the cycle (i.e. clock LOW-to-HIGH transition) that each input must be stable to guarantee that the correct data is written into one of the internal registers.

Measurements are made at 1.5V with  $V_{IL} = 0V$  and  $V_{IH} = 3.0V$ . For three-state disable tests,  $C_L = 5.0pF$  and measurement is to 0.5V change on output voltage level. All outputs have maximum DC loading. The data on this page applies to the following part numbers:

| Operating Range | Part Numbers                   | Power Supply    | Temperature Range                     |
|-----------------|--------------------------------|-----------------|---------------------------------------|
| Com'l           | Am2909APC, DC<br>Am2911APC, DC | 5.0V $\pm 5\%$  | $T_A = 0^\circ C$ to $+70^\circ C$    |
| Mil             | Am2909ADM, FM<br>Am2911ADM     | 5.0V $\pm 10\%$ | $T_C = -55^\circ C$ to $+125^\circ C$ |

**TABLE I**  
CYCLE TIME AND CLOCK CHARACTERISTICS

| TIME                    | COMMERCIAL | MILITARY |
|-------------------------|------------|----------|
| Minimum Clock LOW Time  | 30         | 35       |
| Minimum Clock HIGH Time | 30         | 35       |

**TABLE II**  
MAXIMUM COMBINATIONAL PROPAGATION DELAYS  
(all in ns,  $C_L = 50pF$  (except output disable tests))

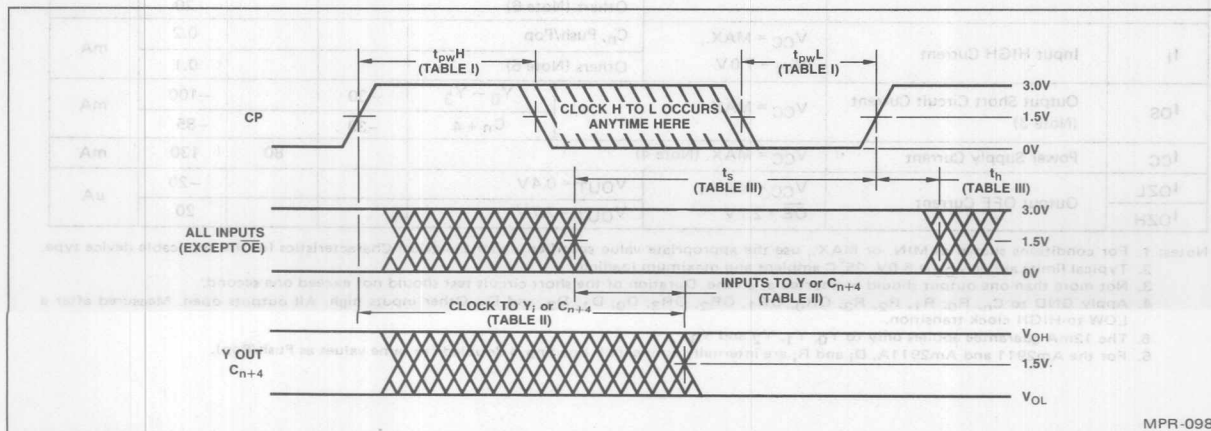
| From Input                      | COMMERCIAL |           | MILITARY |           |
|---------------------------------|------------|-----------|----------|-----------|
|                                 | Y          | $C_{n+4}$ | Y        | $C_{n+4}$ |
| $D_i$                           | 17         | 30        | 20       | 32        |
| $S_0, S_1$                      | 30         | 48        | 40       | 50        |
| $OR_i$                          | 17         | 30        | 20       | 32        |
| $C_n$                           | —          | 14        | —        | 16        |
| ZERO                            | 30         | 48        | 40       | 50        |
| $\overline{OE}$ LOW (enable)    | 25         | —         | 25       | —         |
| $\overline{OE}$ HIGH (disable)  | 25         | —         | 25       | —         |
| Clock $\uparrow$ $S_1 S_0 = LH$ | 43         | 55        | 50       | 62        |
| Clock $\uparrow$ $S_1 S_0 = LL$ | 43         | 55        | 50       | 62        |
| Clock $\uparrow$ $S_1 S_0 = HL$ | 80         | 95        | 90       | 102       |

**TABLE III**  
GUARANTEED SET-UP AND HOLD TIMES (all in ns) (Note 1)

| From Input      | Notes | COMMERCIAL  |           | MILITARY    |           |
|-----------------|-------|-------------|-----------|-------------|-----------|
|                 |       | Set-Up Time | Hold Time | Set-Up Time | Hold Time |
| $\overline{RE}$ |       | 22          | 5         | 22          | 5         |
| $R_i$           | 2     | 10          | 5         | 12          | 5         |
| PUSH/POP        |       | 26          | 6         | 30          | 7         |
| $\overline{FE}$ |       | 26          | 5         | 30          | 5         |
| $C_n$           |       | 28          | 5         | 30          | 5         |
| $D_i$           | 2     | 30          | 0         | 35          | 3         |
| $OR_i$          |       | 30          | 0         | 35          | 3         |
| $S_0, S_1$      |       | 45          | 0         | 50          | 0         |
| ZERO            |       | 45          | 0         | 50          | 0         |

Notes: 1. All times relative to clock LOW-to-HIGH transition.

2. On Am2911A,  $R_i$  and  $D_i$  are internally connected together and labeled  $D_i$ . Use  $R_i$  set-up and hold times when D inputs are used to load register.





# Am2909A and Am2911A SWITCHING CHARACTERISTICS TYPICAL ROOM TEMPERATURE

Tables I, II and III below give typical timing characteristics of the Am2909A and Am2911A at room temperature. The tables are divided into three types of parameters: clock characteristics, combinational delays from inputs to outputs, and set-up and hold time requirements. The latter table defines the time prior to the end of the cycle (i.e., clock LOW-to-HIGH transition) that each input must be stable to guarantee that the correct data is written into one of the internal registers.

Measurements are made at 1.5V with  $V_{IL} = 0V$  and  $V_{IH} = 3.0V$ . For three-state disable tests,  $C_L = 5.0pF$  and measurement is to 0.5V change on output voltage level. All outputs have maximum DC loading. The data on this page applies to the following part numbers:

| Operating Range | Part Numbers                 | Power Supply    | Temperature Range                     |
|-----------------|------------------------------|-----------------|---------------------------------------|
| Com'l           | Am2909PC, DC<br>Am2911PC, DC | 5.0V $\pm 5\%$  | $T_A = 0^\circ C$ to $+70^\circ C$    |
| Mil             | Am2909DM, FM<br>Am2911DM     | 5.0V $\pm 10\%$ | $T_C = -55^\circ C$ to $+125^\circ C$ |

**TABLE I**  
CYCLE TIME AND CLOCK CHARACTERISTICS

| TIME                    | COMMERCIAL | MILITARY |
|-------------------------|------------|----------|
| Minimum Clock LOW Time  | 30         | 35       |
| Minimum Clock HIGH Time | 30         | 35       |

**TABLE II**  
MAXIMUM COMBINATIONAL PROPAGATION DELAYS  
(all in ns,  $C_L = 50pF$  (except output disable tests))

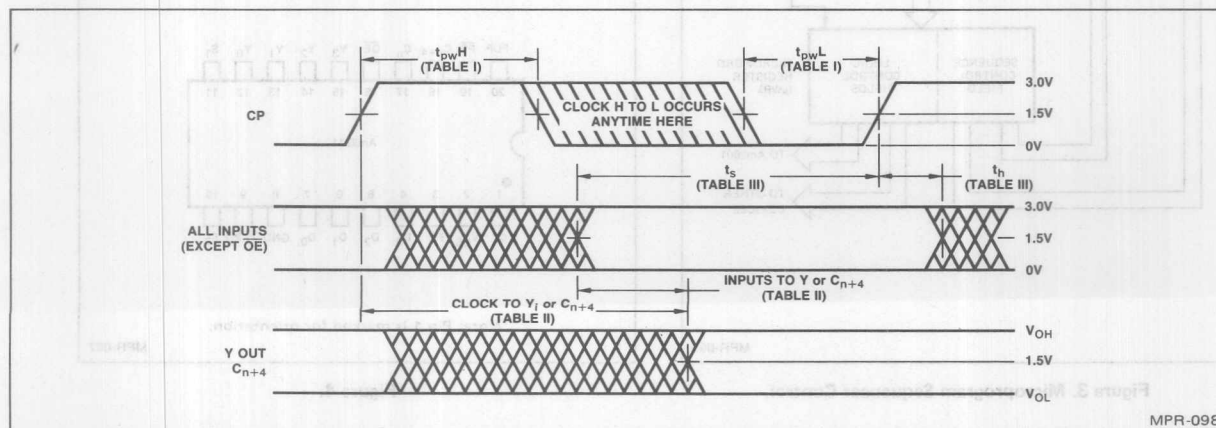
| From Input                      | TYPICAL ROOM TEMPERATURE |           | Y | $C_{n+4}$ |
|---------------------------------|--------------------------|-----------|---|-----------|
|                                 | Y                        | $C_{n+4}$ |   |           |
| $D_i$                           | 10                       | 10        |   |           |
| $S_0, S_1$                      | 18                       | 18        |   |           |
| $OR_i$                          | 14                       | 14        |   |           |
| $C_n$                           | —                        | 9         | — | —         |
| ZERO                            | 18                       | 18        |   |           |
| OE LOW (enable)                 | 13                       | —         | — | —         |
| OE HIGH (disable)               | 13                       | —         | — | —         |
| Clock $\uparrow$ $S_1 S_0 = LH$ | 26                       | 24        |   |           |
| Clock $\uparrow$ $S_1 S_0 = LL$ | 26                       | 24        |   |           |
| Clock $\uparrow$ $S_1 S_0 = HL$ | 36                       | 35        |   |           |

**TABLE III**  
SET-UP AND HOLD TIMES (all in ns) (Note 1)

| From Input      | Notes | TYPICAL ROOM TEMPERATURE |           | Set-Up Time | Hold Time |
|-----------------|-------|--------------------------|-----------|-------------|-----------|
|                 |       | Set-Up Time              | Hold Time |             |           |
| $\overline{RE}$ |       | 9                        | 0         |             |           |
| $R_i$           | 2     | 4                        | 0         |             |           |
| PUSH/POP        |       | 11                       | 0         |             |           |
| $\overline{FE}$ |       | 12                       | 0         |             |           |
| $C_n$           |       | 8                        | 0         |             |           |
| $D_i$           | 2     | 11                       | 0         |             |           |
| $OR_i$          |       | 11                       | 0         |             |           |
| $S_0, S_1$      |       | 15                       | 0         |             |           |
| ZERO            |       | 15                       | 0         |             |           |

Notes: 1. All times relative to clock LOW-to-HIGH transition.

2. On Am2911,  $R_i$  and  $D_i$  are internally connected together and labeled  $D_i$ . Use  $R_i$  set-up and hold times when  $D_i$  inputs are used to load register.



MPR-098

Am2909/2911 - Am2909A/2911A  
various internal and external registers and signals used with the Am2909. Since its principle application is as a controller for a microprogram store, it is necessary to define some signals associated with the microcode itself. Figure 3 illustrates the basic interconnection of Am2909, memory, and microinstruction register. The definitions here apply to this architecture.

#### Inputs to Am2909/Am2911

|                      |   |
|----------------------|---|
| $S_1, S_0$           | Control lines for address source selection  |
| $\overline{FE}, PUP$ | Control lines for push/pop stack  |
| $\overline{RE}$      | Enable line for internal address register   |
| $OR_i$               | Logic OR inputs on each address output line   |
| $\overline{ZERO}$    | Logic AND input on the output lines   |
| $\overline{OE}$      | Output Enable. When $\overline{OE}$ is HIGH, the Y outputs are OFF (high impedance) |
| $C_n$                | Carry-in to the incrementer   |
| $R_i$                | Inputs to the internal address register   |
| $D_i$                | Direct inputs to the multiplexer  |
| $CP$                 | Clock input to the AR and $\mu PC$ register and Push-Pop stack                      |

#### Outputs from the Am2909/Am2911

|       |  |
|-------|--|
| $Y_i$ | Address outputs from Am2909. (Address inputs to control memory.) |
|-------|--|

#### Internal Signals

|           |  |
|-----------|--|
| $\mu PC$  | Contents of the microprogram counter   |
| AR        | Contents of the address/holding register   |
| STK0-STK3 | Contents of the push/pop stack. By definition, the word in the four-by-four file, addressed by the stack pointer is STK0. Conceptually data is pushed into the stack at STK0; a subsequent push moves STK0 to STK1; a pop implies STK3 $\rightarrow$ STK2 $\rightarrow$ STK1 $\rightarrow$ STK0. Physically, only the stack pointer changes when a push or pop is performed. The data does not move. I/O occurs at STK0. |
| SP        | Contents of the stack pointer  |

#### External to the Am2909/Am2911

|          |   |
|----------|---|
| A        | Address to the control memory   |
| I(A)     | Instruction in control memory at address A  |
| $\mu WR$ | Contents of the microword register (at output of control memory). The microword register contains the instruction currently being executed. |
| $T_n$    | Time period (cycle) n   |

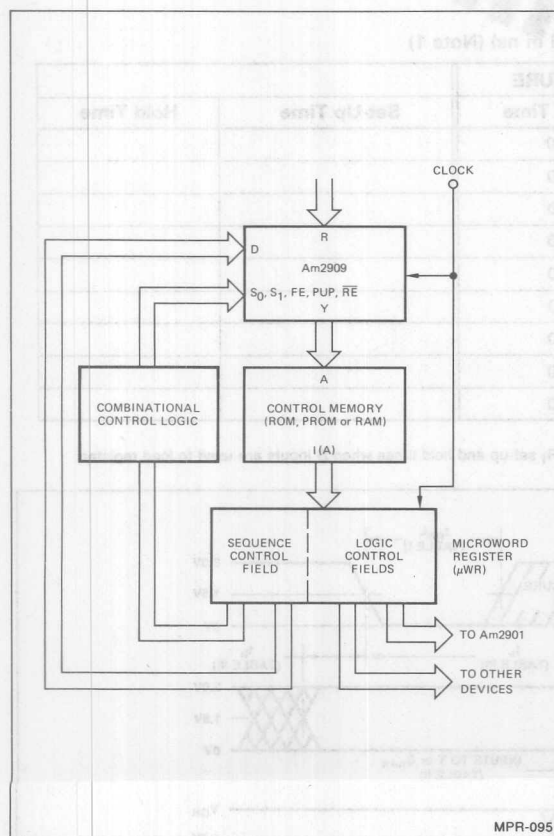


Figure 3. Microprogram Sequencer Control.

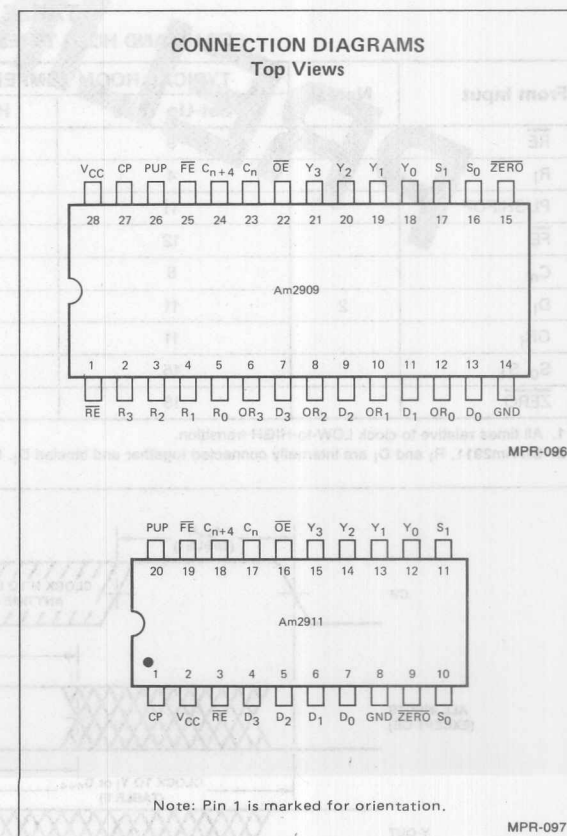


Figure 4.

## OPERATION OF THE Am2909/Am2911

Figure 5 lists the select codes for the multiplexer. The two bits applied from the microword register (and additional combinational logic for branching) determine which data source contains the address for the next microinstruction. The contents of the selected source will appear on the Y outputs. Figure 5 also shows the truth table for the output control and

for the control of the push/pop stack. Figure 6 shows in detail the effect of  $S_0$ ,  $S_1$ ,  $\overline{FE}$  and PUP on the Am2909. These four signals define what address appears on the Y outputs and what the state of all the internal registers will be following the clock LOW-to-HIGH edge. In this illustration, the microprogram counter is assumed to contain initially some word J, the address register some word K, and the four words in the push/pop stack contain  $R_a$  through  $R_d$ .

| Address Selection |       |       |                          | Output Control |        |                   |                 |
|-------------------|-------|-------|--------------------------|----------------|--------|-------------------|-----------------|
| OCTAL             | $S_1$ | $S_0$ | SOURCE FOR Y OUTPUTS     | SYMBOL         | $OR_i$ | $\overline{ZERO}$ | $\overline{OE}$ |
| 0                 | L     | L     | Microprogram Counter     | $\mu PC$       | X      | X                 | H               |
| 1                 | L     | H     | Address/Holding Register | AR             | X      | L                 | L               |
| 2                 | H     | L     | Push-Pop stack           | STK0           | H      | H                 | L               |
| 3                 | H     | H     | Direct inputs            | $D_i$          | L      | H                 | L               |

| Output Control |                   |                 | $Y_i$                        |
|----------------|-------------------|-----------------|------------------------------|
| $OR_i$         | $\overline{ZERO}$ | $\overline{OE}$ | Z                            |
| X              | L                 | L               | L                            |
| H              | H                 | L               | H                            |
| L              | H                 | L               | Source selected by $S_0 S_1$ |

Z = High Impedance

| Synchronous Stack Control |     |   |
|---------------------------|-----|---|
| $\overline{FE}$           | PUP | PUSH-POP STACK CHANGE                                   |
| H                         | X   | No change   |
| L                         | H   | Increment stack pointer, then push current PC onto STK0 |
| L                         | L   | Pop stack (decrement stack pointer)                     |

H = High  
L = Low  
X = Don't Care

Figure 5.

| CYCLE    | $S_1, S_0, \overline{FE}, PUP$ | $\mu PC$     | REG    | STK0           | STK1           | STK2           | STK3           | $Y_{OUT}$  | COMMENT                                   | PRINCIPLE USE    |
|----------|--------------------------------|--------------|--------|----------------|----------------|----------------|----------------|------------|---|------------------|
| N<br>N+1 | 0 0 0 0<br>—                   | J<br>J+1     | K<br>K | $R_a$<br>$R_b$ | $R_b$<br>$R_c$ | $R_c$<br>$R_d$ | $R_d$<br>$R_a$ | J<br>—     | Pop Stack                                 | End Loop         |
| N<br>N+1 | 0 0 0 1<br>—                   | J<br>J+1     | K<br>K | $R_a$<br>J     | $R_b$<br>$R_a$ | $R_c$<br>$R_b$ | $R_d$<br>$R_c$ | J<br>—     | Push $\mu PC$                             | Set-up Loop      |
| N<br>N+1 | 0 0 1 X<br>—                   | J<br>J+1     | K<br>K | $R_a$<br>$R_a$ | $R_b$<br>$R_b$ | $R_c$<br>$R_c$ | $R_d$<br>$R_d$ | J<br>—     | Continue                                  | Continue         |
| N<br>N+1 | 0 1 0 0<br>—                   | J<br>K+1     | K<br>K | $R_a$<br>$R_b$ | $R_b$<br>$R_c$ | $R_c$<br>$R_d$ | $R_d$<br>$R_a$ | K<br>—     | Pop Stack;<br>Use AR for Address          | End Loop         |
| N<br>N+1 | 0 1 0 1<br>—                   | J<br>K+1     | K<br>K | $R_a$<br>J     | $R_b$<br>$R_a$ | $R_c$<br>$R_b$ | $R_d$<br>$R_c$ | K<br>—     | Push $\mu PC$ ;<br>Jump to Address in AR  | JSR AR           |
| N<br>N+1 | 0 1 1 X<br>—                   | J<br>K+1     | K<br>K | $R_a$<br>$R_a$ | $R_b$<br>$R_b$ | $R_c$<br>$R_c$ | $R_d$<br>$R_d$ | K<br>—     | Jump to Address in AR                     | JMP AR           |
| N<br>N+1 | 1 0 0 0<br>—                   | J<br>$R_a+1$ | K<br>K | $R_a$<br>$R_b$ | $R_b$<br>$R_c$ | $R_c$<br>$R_d$ | $R_d$<br>$R_a$ | $R_a$<br>— | Jump to Address in STK0;<br>Pop Stack     | RTS              |
| N<br>N+1 | 1 0 0 1<br>—                   | J<br>$R_a+1$ | K<br>K | $R_a$<br>J     | $R_b$<br>$R_a$ | $R_c$<br>$R_b$ | $R_d$<br>$R_c$ | $R_a$<br>— | Jump to Address in STK0;<br>Push $\mu PC$ |                  |
| N<br>N+1 | 1 0 1 X<br>—                   | J<br>$R_a+1$ | K<br>K | $R_a$<br>$R_a$ | $R_b$<br>$R_b$ | $R_c$<br>$R_c$ | $R_d$<br>$R_d$ | $R_a$<br>— | Jump to Address in STK0                   | Stack Ref (Loop) |
| N<br>N+1 | 1 1 0 0<br>—                   | J<br>D+1     | K<br>K | $R_a$<br>$R_b$ | $R_b$<br>$R_c$ | $R_c$<br>$R_d$ | $R_d$<br>$R_a$ | D<br>—     | Pop Stack;<br>Jump to Address on D        | End Loop         |
| N<br>N+1 | 1 1 0 1<br>—                   | J<br>D+1     | K<br>K | $R_a$<br>J     | $R_b$<br>$R_a$ | $R_c$<br>$R_b$ | $R_d$<br>$R_c$ | D<br>—     | Jump to Address on D;<br>Push $\mu PC$    | JSR D            |
| N<br>N+1 | 1 1 1 X<br>—                   | J<br>D+1     | K<br>K | $R_a$<br>$R_b$ | $R_b$<br>$R_c$ | $R_c$<br>$R_d$ | $R_d$<br>$R_d$ | D<br>—     | Jump to Address on D                      | JMP D            |

X = Don't care, 0 = LOW, 1 = HIGH, Assume  $C_n$  = HIGH  
Note: STK0 is the location addressed by the stack pointer.

Figure 6. Output and Internal Next-Cycle Register States for Am2909/Am2911.

Figure 7 illustrates the execution of a subroutine using the Am2909. The configuration of Figure 3 is assumed. The instruction being executed at any given time is the one contained in the microword register ( $\mu$ WR). The contents of the  $\mu$ WR also controls (indirectly, perhaps) the four signals  $S_0$ ,  $S_1$ ,  $\overline{FE}$ , and PUP. The starting address of the subroutine is applied to the D inputs of the Am2909 at the appropriate time.

In the columns on the left is the sequence of microinstructions to be executed. At address J+2, the sequence control portion of the microinstruction contains the command "Jump to sub-

routine at A". At the time  $T_2$ , this instruction is in the  $\mu$ WR, and the Am2909 inputs are set-up to execute the jump and save the return address. The subroutine address A is applied to the D inputs from the  $\mu$ WR and appears on the Y outputs. The first instruction of the subroutine, I(A), is accessed and is at the inputs of the  $\mu$ WR. On the next clock transition, I(A) is loaded into the  $\mu$ WR for execution, and the return address J+3 is pushed onto the stack. The return instruction is executed at  $T_5$ . Figure 8 is a similar timing chart showing one subroutine linking to a second, the latter consisting of only one microinstruction.

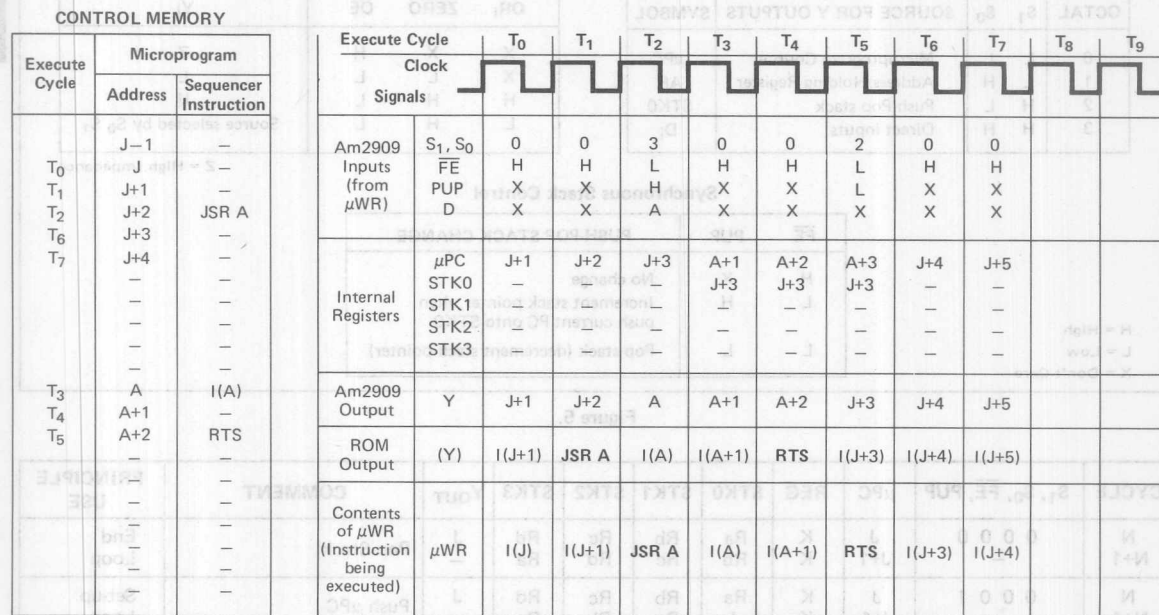


Figure 7. Subroutine Execution.

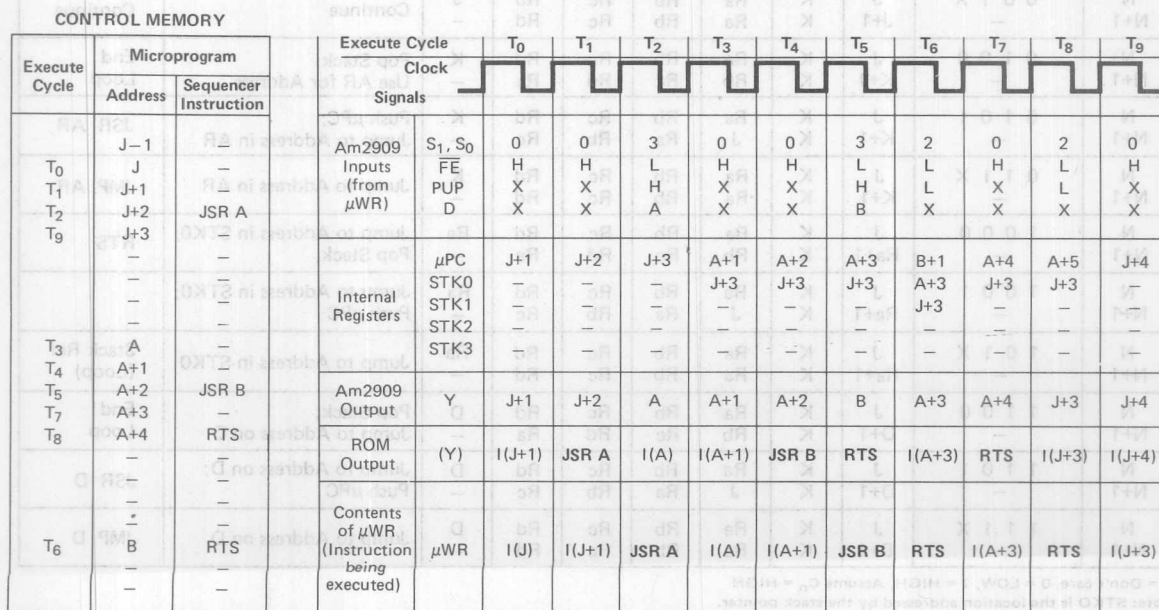
 $C_n = \text{HIGH}$ 

Figure 8. Two Nested Subroutines. Routine B is Only One Instruction.

 $C_n = \text{HIGH}$



## USING THE Am2909 AND Am2911

The Am2909 and Am2911 are four-bit slice sequencers which are cascaded to form a microprogram memory address generator. Both products make available to the user several lines which are used to directly control the internal holding register, multiplexer and stack. By appropriate control of these lines, the user can implement any desired set of sequence control functions; by cascading parts he can generate any desired address length. These two qualities set the Am2909 and Am2911 apart from the Am2910, which is architecturally similar, but is fixed at 12 bits in length and has a fixed set of 16 sequence control instructions. The Am2909 or Am2911 should be selected instead of the Am2910 under the following conditions:

- Address less than 8 bits and not likely to be expanded
- Address longer than 12 bits

- More complex instruction set needed than is available on Am2910

## Architecture of the Control Unit

The recommended architecture using the Am2909 or Am2911 is shown in Figure 1. Note that the path from the pipeline register output through the next address logic, multiplexer, and microprogram memory is all combinational. The pipeline register contains the current microinstruction being executed. A portion of that microinstruction consists of a sequence control command such as "continue", "loop", "return-from-subroutine", etc. The bits representing this sequence command are logically combined with bits representing such things as test conditions and system state to generate the required control signals to the Am2909 or Am2911. The block labeled "next address logic" may consist of simple gates, a PROM or a PLA, but it should be all combinational.

2

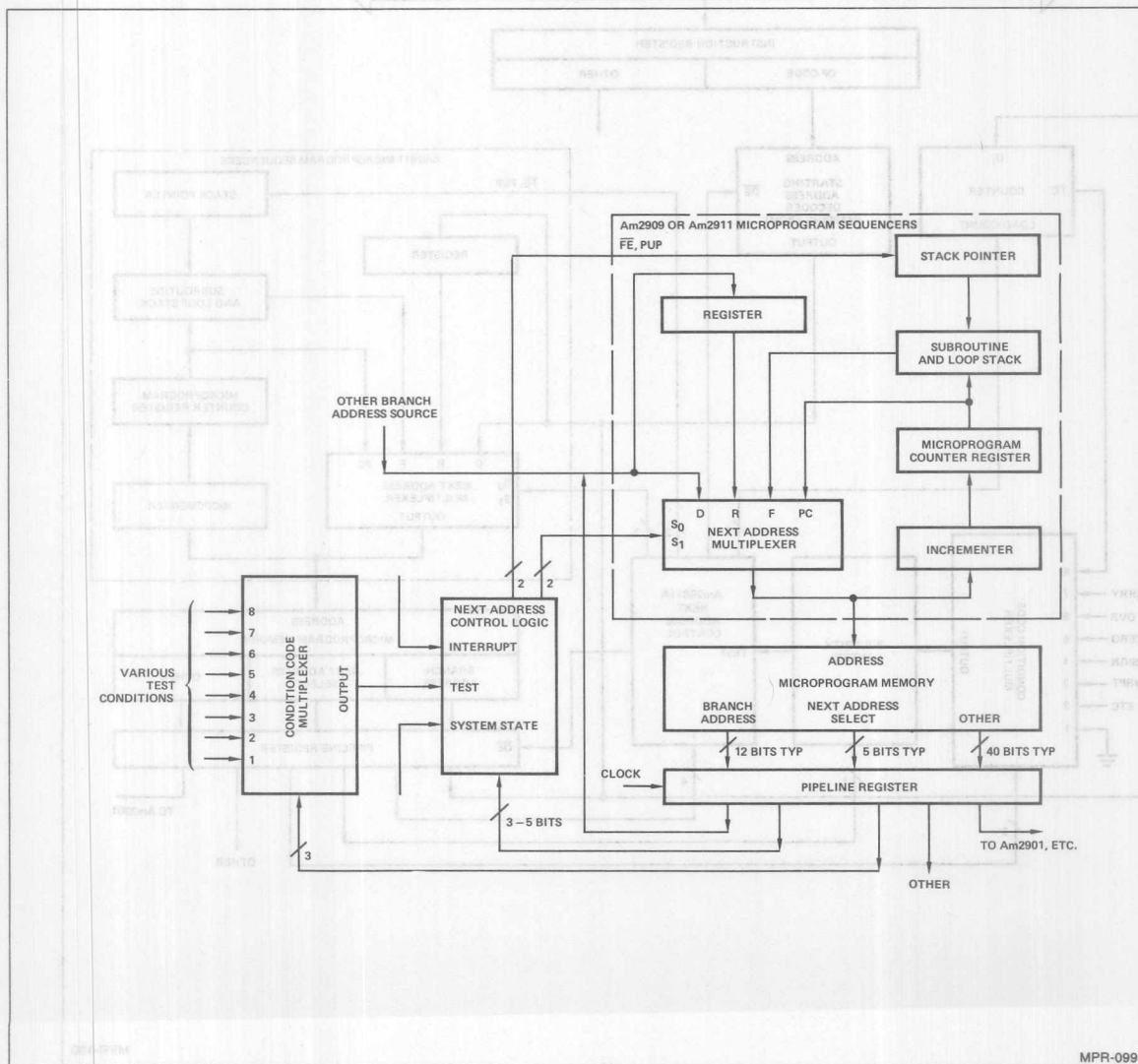


Figure 1. Recommended Computer Control Unit Architecture Using the Am2911 or Am2909.

Figure 2 shows the CCU of Figure 1 with the Am29811A in place. The Am29811A, in addition to controlling the Am2911,

outputs for each instruction. Generating any instruction set consists simply of writing a truth table and designing combinational logic to implement it. For more detailed information refer to "The Microprogramming Handbook".

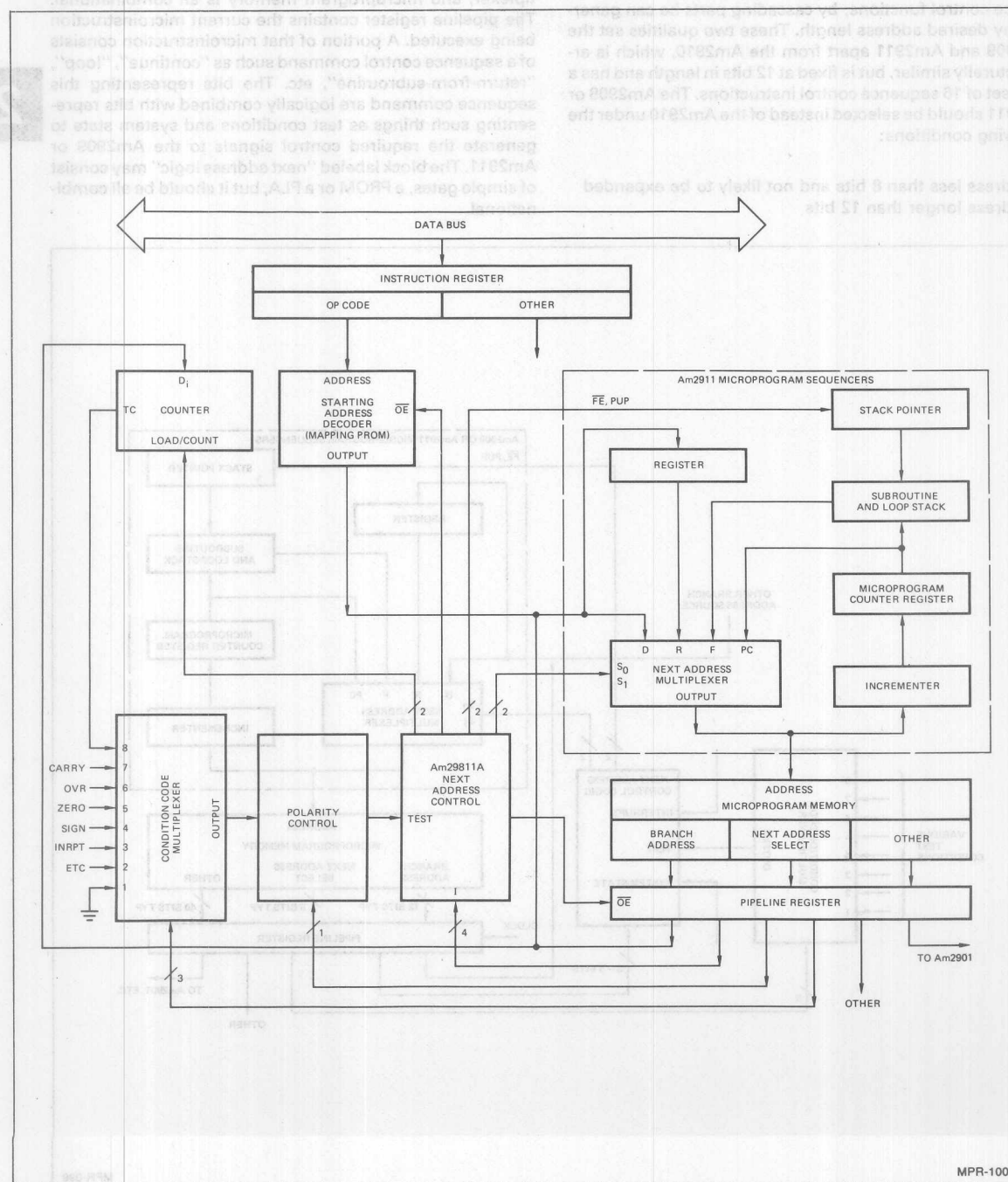


Figure 2. A Typical Computer Control Unit Using the Am2911 and Am29811A.

Am29811A FUNCTION TABLE

| MNEMONIC | INSTRUCTION<br>I <sub>3</sub> I <sub>2</sub> I <sub>1</sub> I <sub>0</sub> | INPUTS                |               |                     | OUTPUTS |         |       |      |  |
|----------|--|-----------------------|---------------|---------------------|---------|---------|-------|------|--|
|          |  | FUNCTION              | TEST<br>INPUT | NEXT ADDR<br>SOURCE | FILE    | COUNTER | MAP-E | PL-E |  |
| JZ       | L L L L  | JUMP ZERO             | X             | D                   | HOLD    | L L*    | H     | L    |  |
| CJS      | L L L H  | COND JSB PL           | L             | PC                  | HOLD    | HOLD    | H     | L    |  |
|          |  |                       | H             | D                   | PUSH    | HOLD    | H     | L    |  |
| JMAP     | L L H L  | JUMP MAP              | X             | D                   | HOLD    | HOLD    | L     | H    |  |
| CJP      | L L H H  | COND JUMP PL          | L             | PC                  | HOLD    | HOLD    | H     | L    |  |
|          |  |                       | H             | D                   | HOLD    | HOLD    | H     | L    |  |
| PUSH     | L H L L  | PUSH/COND LD CNTR     | L             | PC                  | PUSH    | HOLD    | H     | L    |  |
|          |  |                       | H             | PC                  | PUSH    | LOAD    | H     | L    |  |
| JSRP     | L H L H  | COND JSB R/PL         | L             | R                   | PUSH    | HOLD    | H     | L    |  |
|          |  |                       | H             | D                   | PUSH    | HOLD    | H     | L    |  |
| CJV      | L H H L  | COND JUMP VECTOR      | L             | PC                  | HOLD    | HOLD    | H     | H    |  |
|          |  |                       | H             | D                   | HOLD    | HOLD    | H     | H    |  |
| JRP      | L H H H  | COND JUMP R/PL        | L             | R                   | HOLD    | HOLD    | H     | L    |  |
|          |  |                       | H             | D                   | HOLD    | HOLD    | H     | L    |  |
| RFCT     | H L L L  | REPEAT LOOP, CNTR ≠ 0 | L             | F                   | HOLD    | DEC     | H     | L    |  |
|          |  |                       | H             | PC                  | POP     | HOLD    | H     | L    |  |
| RPCT     | H L L H  | REPEAT PL, CNTR ≠ 0   | L             | D                   | HOLD    | DEC     | H     | L    |  |
|          |  |                       | H             | PC                  | HOLD    | HOLD    | H     | L    |  |
| CRTN     | H L H L  | COND RTN              | L             | PC                  | HOLD    | HOLD    | H     | L    |  |
|          |  |                       | H             | F                   | POP     | HOLD    | H     | L    |  |
| CJPP     | H L H H  | COND JUMP PL & POP    | L             | PC                  | HOLD    | HOLD    | H     | L    |  |
|          |  |                       | H             | D                   | POP     | HOLD    | H     | L    |  |
| LDCT     | H H L L  | LOAD CNTR & CONTINUE  | X             | PC                  | HOLD    | LOAD    | H     | L    |  |
| LOOP     | H H L H  | TEST END LOOP         | L             | F                   | HOLD    | HOLD    | H     | L    |  |
|          |  |                       | H             | PC                  | POP     | HOLD    | H     | L    |  |
| CONT     | H H H L  | CONTINUE              | X             | PC                  | HOLD    | HOLD    | H     | L    |  |
| JP       | H H H H  | JUMP PL               | X             | D                   | HOLD    | HOLD    | H     | L    |  |

L = LOW

DEC = Decrement

H = HIGH

\*LL = Special Case

X = Don't Care

Am29811A TRUTH TABLE

| MNEMONIC | FUNCTION             | INPUTS         |                |                |                |      | OUTPUTS          |                |      |     |         |    |     |     |
|----------|----------------------|----------------|----------------|----------------|----------------|------|------------------|----------------|------|-----|---------|----|-----|-----|
|          |                      | I <sub>3</sub> | I <sub>2</sub> | I <sub>1</sub> | I <sub>0</sub> | TEST | NEXT ADDR SOURCE |                | FILE |     | COUNTER |    | MAP | PLE |
|          |                      |                |                |                |                |      | S <sub>1</sub>   | S <sub>0</sub> | FE   | PUP | LOAD    | EN |     |     |
|          | PIN NO.              | 14             | 13             | 12             | 11             | 10   | 4                | 5              | 3    | 2   | 6       | 7  | 1   | 9   |
| JZ       | JUMP ZERO            | L              | L              | L              | L              | L    | H                | H              | H    | H   | L       | L  | H   | L   |
|          |                      | L              | L              | L              | L              | H    | H                | H              | H    | H   | L       | L  | H   | L   |
| CJS      | COND JSB PL          | L              | L              | L              | H              | L    | L                | L              | H    | H   | H       | H  | H   | L   |
|          |                      | L              | L              | L              | H              | H    | H                | H              | L    | H   | H       | H  | H   | L   |
| JMAP     | JUMP MAP             | L              | L              | H              | L              | L    | H                | H              | H    | H   | H       | H  | L   | H   |
|          |                      | L              | L              | H              | L              | H    | H                | H              | H    | H   | H       | H  | L   | H   |
| CJP      | COND JUMP PL         | L              | L              | H              | H              | L    | L                | L              | H    | H   | H       | H  | H   | L   |
|          |                      | L              | L              | H              | H              | H    | H                | H              | H    | H   | H       | H  | H   | L   |
| PUSH     | PUSH/COND LD CNTR    | L              | H              | L              | L              | L    | L                | L              | L    | H   | H       | H  | H   | L   |
|          |                      | L              | H              | L              | L              | H    | L                | L              | L    | H   | L       | H  | H   | L   |
| JSRP     | COND JSB R/PL        | L              | H              | L              | H              | L    | L                | H              | L    | H   | H       | H  | H   | L   |
|          |                      | L              | H              | L              | H              | H    | H                | H              | L    | H   | H       | H  | H   | L   |
| CJV      | COND JUMP VECTOR     | L              | H              | H              | L              | L    | L                | L              | H    | H   | H       | H  | H   | H   |
|          |                      | L              | H              | H              | L              | H    | H                | H              | H    | H   | H       | H  | H   | H   |
| JRP      | COND JUMP R/PL       | L              | H              | H              | H              | L    | L                | H              | H    | H   | H       | H  | H   | L   |
|          |                      | L              | H              | H              | H              | H    | H                | H              | H    | H   | H       | H  | H   | L   |
| RFCT     | REPEAT LOOP, CTR ≠ 0 | H              | L              | L              | L              | L    | H                | L              | H    | L   | H       | L  | H   | L   |
|          |                      | H              | L              | L              | L              | H    | L                | L              | L    | L   | H       | H  | H   | L   |
| RPCT     | REPEAT PL, CTR ≠ 0   | H              | L              | L              | H              | L    | H                | H              | H    | H   | H       | L  | H   | L   |
|          |                      | H              | L              | L              | H              | H    | L                | L              | H    | H   | H       | H  | H   | L   |
| CRTN     | COND RTN             | H              | L              | H              | L              | L    | L                | L              | H    | L   | H       | H  | H   | L   |
|          |                      | H              | L              | H              | L              | H    | H                | L              | L    | L   | H       | H  | H   | L   |
| CJPP     | COND JUMP PL & POP   | H              | L              | H              | H              | L    | L                | L              | H    | L   | H       | H  | H   | L   |
|          |                      | H              | L              | H              | H              | H    | H                | H              | L    | L   | H       | H  | H   | L   |
| LDCT     | LD CNTR & CONTINUE   | H              | H              | L              | L              | L    | L                | L              | H    | H   | L       | H  | H   | L   |
|          |                      | H              | H              | L              | L              | H    | L                | L              | H    | H   | L       | H  | H   | L   |
| LOOP     | TEST END LOOP        | H              | H              | L              | H              | L    | H                | L              | H    | L   | H       | H  | H   | L   |
|          |                      | H              | H              | L              | H              | H    | L                | L              | L    | L   | H       | H  | H   | L   |
| CONT     | CONTINUE             | H              | H              | H              | L              | L    | L                | L              | H    | H   | H       | H  | H   | L   |
|          |                      | H              | H              | L              | L              | H    | L                | L              | H    | H   | H       | H  | H   | L   |
| JP       | JUMP PL              | H              | H              | H              | H              | L    | H                | H              | H    | H   | H       | H  | H   | L   |
|          |                      | H              | H              | H              | H              | H    | H                | H              | H    | H   | H       | H  | H   | L   |

L = LOW  
H = HIGH

Figure 3.

## Expansion of the Am2909 or Am2911

Figure 4 shows the interconnection of three Am2911's to form a 12-bit sequencer. Note that the only interconnection between packages, other than the common clock and control lines, is the ripple carry between  $\mu$ PC incrementors. This carry path is not in the critical speed path if the Am2911 Y outputs drive the microprogram memory, because the ripple carry occurs in parallel with the memory access time. If, on the other hand, a micro-address register is placed at the Am2911 output, then the carry may lie in the critical speed path, since the last carry-in must be stable for a set-up time prior to the clock.

## Selecting Between the Am2909 and Am2911

The difference between the Am2909 and the Am2911 involves two signals: the data inputs to the holding register

and the "OR" inputs. In the Am2909, separate four-bit fields are provided for the holding register and the direct branch inputs to the multiplexer. In the Am2911, these fields are internally tied together. This may affect the design of the branch address system, as shown in Figure 5. Using the Am2909, the register inputs may be connected directly to the microprogram memory; the internal register replaces part of the pipeline register. The direct (D) inputs may be tied to the mapping logic which translates instruction op codes into microprogram addresses. While the same technique might be used with the Am2911, it is more common to connect the Am2911's D inputs to a branch address bus onto which various sources may be enabled. Shown in Figure 5 is a pipeline register and a mapping ROM. Other sources might also be applied to the same bus. The internal register is used only for temporary storage of some previous branch address.

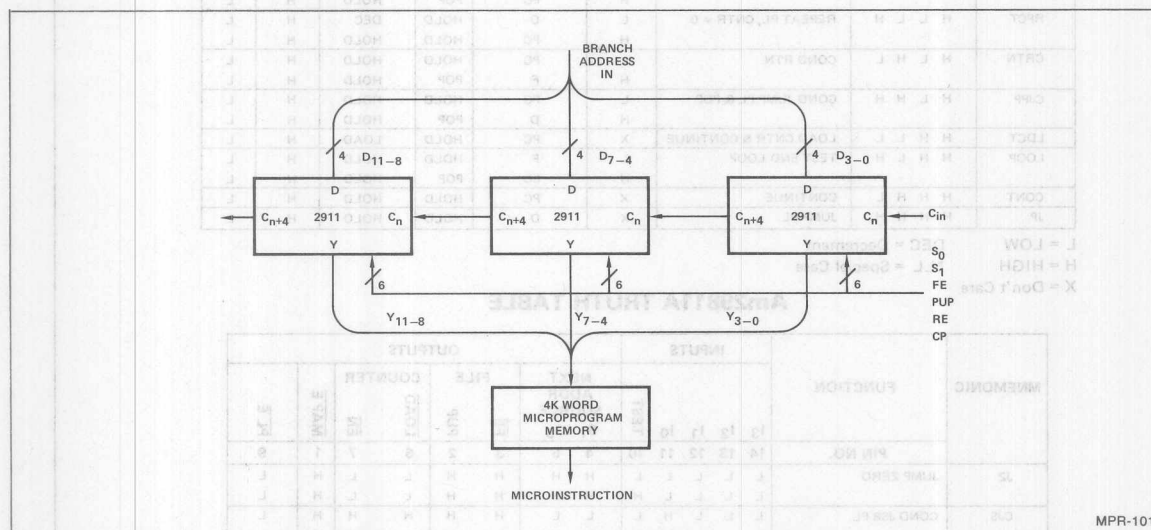


Figure 4. Twelve Bit Sequencer.

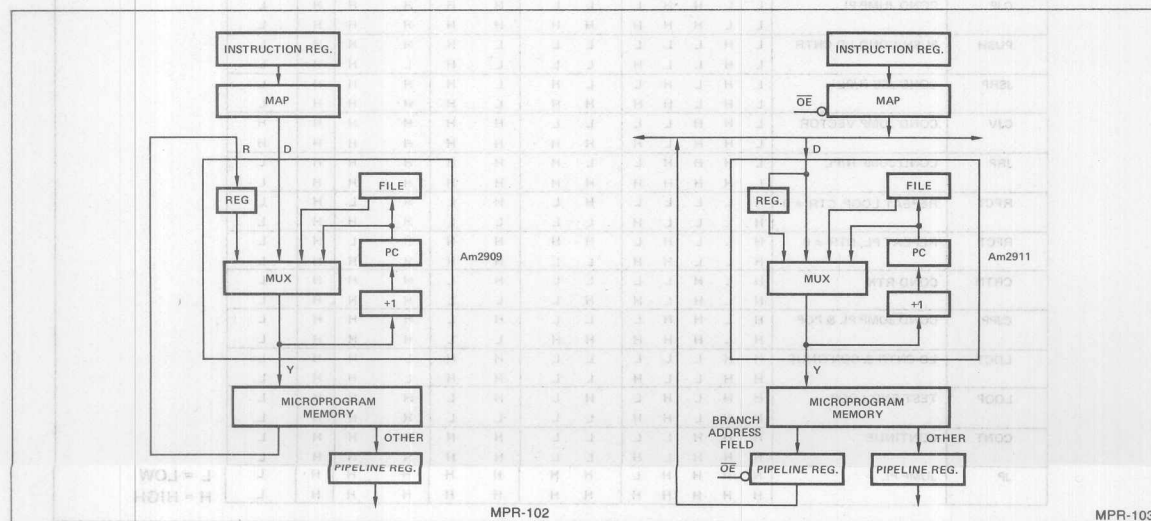


Figure 5. Branch Address Structures.



The second difference between the Am2909 and Am2911 is that the Am2909 has OR inputs available on each address output line. These pins can be used to generate multi-way single-cycle branches by simply tying several test conditions into the OR lines. See Figure 6. Typically, a branch is taken to an address with zeroes in the least significant bits. These bits are replaced with 1's or 0's by test conditions applied to the OR lines. In Figure 6, the states of the two test conditions X and Y result in a branch to 1100, 1101, 1110, or 1111.

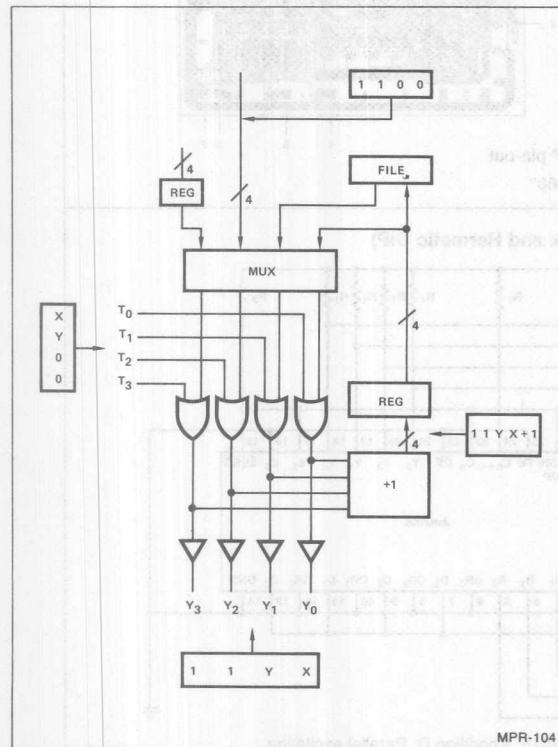


Figure 6. Use of OR Inputs to Obtain 4-Way Branch.

The Am29803A has been designed to selectively apply any or all of four different test conditions to an Am2909. Figure 7 shows the truth table for this device. A nice trade off between flexibility and board space is achieved by using a single 28-pin Am2909 for the least significant four bits of a sequencer, and using the space-saving 20-pin Am2911's for the remainder of the bits. A detailed logic design for such a system is contained in The Microprogramming Handbook.

#### How to Perform Some Common Functions with the Am2909 or Am2911

##### 1. CONTINUE

| MUX/Y <sub>OUT</sub> | STACK | C <sub>n</sub> | S <sub>1</sub> | S <sub>0</sub> | $\overline{FE}$ | PUP |
|----------------------|-------|----------------|----------------|----------------|-----------------|-----|
| PC                   | HOLD  | 1              | 0              | 0              | 1               | X   |

Contents of PC placed on Y outputs; PC incremented.

##### 2. BRANCH

| MUX/Y <sub>OUT</sub> | STACK | C <sub>n</sub> | S <sub>1</sub> | S <sub>0</sub> | $\overline{FE}$ | PUP |
|----------------------|-------|----------------|----------------|----------------|-----------------|-----|
| D                    | HOLD  | 1              | 1              | 1              | 1               | X   |

Feed data on D inputs straight through to memory address lines. Increment address and place in PC.

##### 3. JUMP-TO-SUBROUTINE

| MUX/Y <sub>OUT</sub> | STACK | C <sub>n</sub> | S <sub>1</sub> | S <sub>0</sub> | $\overline{FE}$ | PUP |
|----------------------|-------|----------------|----------------|----------------|-----------------|-----|
| D                    | PUSH  | 1              | 1              | 1              | 0               | 1   |

Sub-routine address fed from D inputs to memory address. Current PC is pushed onto stack, where it is saved for the return.

##### 4. RETURN-FROM-SUBROUTINE

| MUX/Y <sub>OUT</sub> | STACK | C <sub>n</sub> | S <sub>1</sub> | S <sub>0</sub> | $\overline{FE}$ | PUP |
|----------------------|-------|----------------|----------------|----------------|-----------------|-----|
| STACK                | POP   | 1              | 1              | 0              | 0               | 0   |

The address at the top of the stack is applied to the microprogram memory, and is incremented for PC on the next cycle. The stack is popped to remove the return address.

Am29803A FUNCTION TABLE

|                    | BRANCH ON   | I <sub>3</sub> | I <sub>2</sub> | I <sub>1</sub> | I <sub>0</sub> | OR <sub>3</sub> | OR <sub>2</sub> | OR <sub>1</sub> | OR <sub>0</sub> |
|--------------------|---|----------------|----------------|----------------|----------------|-----------------|-----------------|-----------------|-----------------|
| NONE               | NONE  | L              | L              | L              | L              | L               | L               | L               | L               |
| Two-Way Branches   | T <sub>0</sub>  | L              | L              | L              | H              | L               | L               | L               | T <sub>0</sub>  |
|                    | T <sub>1</sub>  | L              | L              | H              | L              | L               | L               | L               | T <sub>1</sub>  |
|                    | T <sub>2</sub>  | L              | H              | L              | L              | L               | L               | L               | T <sub>2</sub>  |
|                    | T <sub>3</sub>  | H              | L              | L              | L              | L               | L               | L               | T <sub>3</sub>  |
| Four-Way Branches  | T <sub>1</sub> & T <sub>0</sub>                                   | L              | L              | H              | H              | L               | L               | T <sub>1</sub>  | T <sub>0</sub>  |
|                    | T <sub>2</sub> & T <sub>0</sub>                                   | L              | H              | L              | H              | L               | L               | T <sub>2</sub>  | T <sub>0</sub>  |
|                    | T <sub>3</sub> & T <sub>0</sub>                                   | H              | L              | L              | H              | L               | L               | T <sub>3</sub>  | T <sub>0</sub>  |
|                    | T <sub>2</sub> & T <sub>1</sub>                                   | L              | H              | H              | L              | L               | L               | T <sub>2</sub>  | T <sub>1</sub>  |
| Eight-Way Branches | T <sub>3</sub> & T <sub>1</sub>                                   | H              | L              | H              | L              | L               | L               | T <sub>3</sub>  | T <sub>1</sub>  |
|                    | T <sub>3</sub> & T <sub>2</sub>                                   | H              | H              | L              | L              | L               | L               | T <sub>3</sub>  | T <sub>2</sub>  |
|                    | T <sub>2</sub> , T <sub>1</sub> , T <sub>0</sub>                  | L              | H              | H              | H              | L               | T <sub>2</sub>  | T <sub>1</sub>  | T <sub>0</sub>  |
|                    | T <sub>3</sub> , T <sub>1</sub> , T <sub>0</sub>                  | H              | L              | H              | H              | L               | T <sub>3</sub>  | T <sub>1</sub>  | T <sub>0</sub>  |
| Sixteen-Way Branch | T <sub>3</sub> , T <sub>2</sub> , T <sub>0</sub>                  | H              | H              | L              | H              | L               | T <sub>3</sub>  | T <sub>2</sub>  | T <sub>0</sub>  |
|                    | T <sub>3</sub> , T <sub>2</sub> , T <sub>1</sub>                  | H              | H              | H              | L              | L               | T <sub>3</sub>  | T <sub>2</sub>  | T <sub>1</sub>  |
| Sixteen-Way Branch | T <sub>3</sub> , T <sub>2</sub> , T <sub>1</sub> , T <sub>0</sub> | H              | H              | H              | H              | T <sub>3</sub>  | T <sub>2</sub>  | T <sub>1</sub>  | T <sub>0</sub>  |

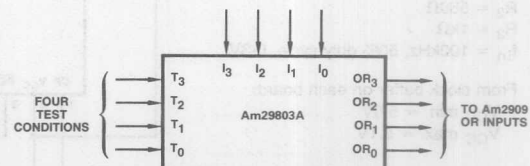
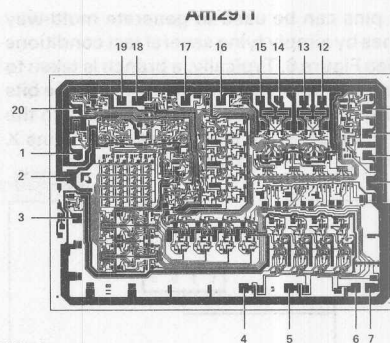
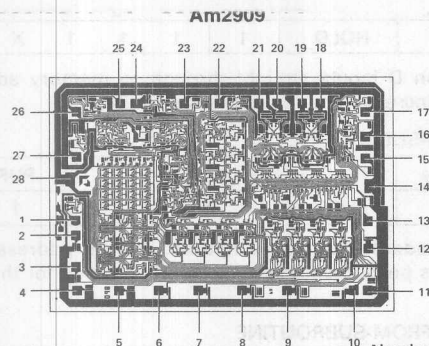


Figure 7.



Numbers correspond to DIP pin-out  
DIE SIZE 0.110" X 0.160"

### Burn-in Circuit for Am2909 (Flatpack and Hermetic DIP)

#### Notes:

Max.  $I_{CC} = 200\text{mA}$

$T_A = +125^\circ\text{C}$

Resistors =  $\pm 5\%$

$R_1 = 390\Omega$

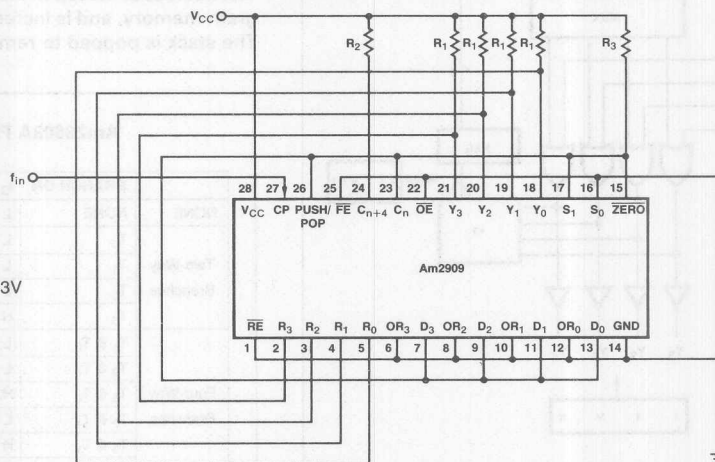
$R_2 = 560\Omega$

$R_3 = 1\text{k}\Omega$

$f_{in} = 100\text{kHz}$ , 50% duty-cycle, 0-3V

$V_{CC}$  min. = 5.0V

$V_{CC}$  max. = 5.1V



This circuit conforms to MIL-STD-883, Method 1005 and 1015, Condition D. Parallel excitation.

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### Burn-in Circuit for Am2911

#### Notes:

Max.  $I_{CC} = 200\text{mA}$

$T_A = +125^\circ\text{C}$

Resistors =  $\pm 5\%$

$R_1 = 390\Omega$

$R_2 = 560\Omega$

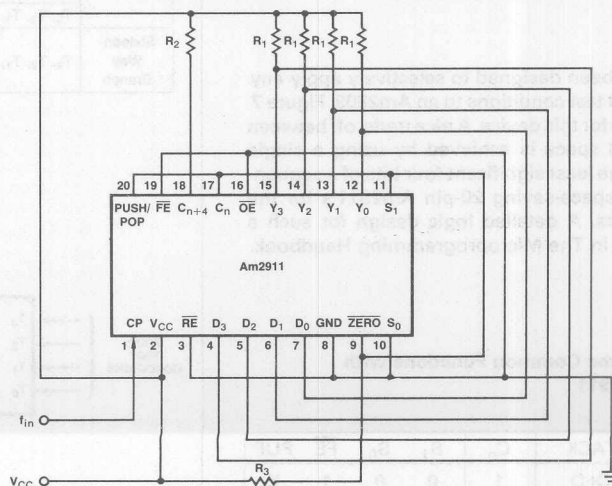
$R_3 = 1\text{k}\Omega$

$f_{in} = 100\text{kHz}$ , 50% duty-cycle, 0-3V

From clock buffer on each board:

$V_{CC}$  min. = 5.0V

$V_{CC}$  max. = 5.1V



This circuit conforms to MIL-STD-883, Method 1005 and 1015, Condition D. Parallel excitation.

MPR-727

## ARCHITECTURE OF THE Am2909/Am2911

The Am2909/Am2911 are bipolar microprogram sequencers intended for use in high-speed microprocessor applications. The device is a cascadable 4-bit slice such that two devices allow addressing of up to 256-words of microprogram and three devices allow addressing of up to 4K words of microprogram. A detailed logic diagram is shown in Figure 2.

The device contains a four-input multiplexer that is used to select either the address register, direct inputs, microprogram counter, or file as the source of the next microinstruction address. This multiplexer is controlled by the  $S_0$  and  $S_1$  inputs.

The address register consists of four D-type, edge triggered flip-flops with a common clock enable. When the address register enable is LOW, new data is entered into the register on the clock LOW-to-HIGH transition. The address register is available at the multiplexer as a source for the next microinstruction address. The direct input is a four-bit field of inputs to the multiplexer and can be selected as the next microinstruction address. On the Am2911, the direct inputs are also used as inputs to the register. This allows an N-way branch where N is any word in the microcode.

The Am2909/Am2911 contains a microprogram counter ( $\mu PC$ ) that is composed of a 4-bit incrementer followed by a 4-bit register. The incrementer has carry-in ( $C_N$ ) and carry-out ( $C_{N+4}$ ) such that cascading to larger word lengths is straightforward. The  $\mu PC$  can be used in either of two ways. When the least significant carry-in to the incrementer is HIGH, the microprogram register is loaded on the next clock cycle with the current Y output word plus one ( $Y+1 \rightarrow \mu PC$ .) Thus sequential microinstructions can be executed. If this least significant  $C_N$  is LOW, the incrementer passes the Y output word unmodified and the microprogram register is loaded with the same Y word on the next clock cycle ( $Y \rightarrow \mu PC$ ). Thus, the same microinstruction can be executed any number of times by using the least significant  $C_N$  as the control.

The last source available at the multiplexer input is the 4 x 4 file (stack). The file is used to provide return address linkage

when executing microsubroutines. The file contains a built-in stack pointer (SP) which always points to the last file word written. This allows stack reference operations (looping) to be performed without a push or pop.

The stack pointer operates as an up/down counter with separate push/pop and file enable inputs. When the file enable input is LOW and the push/pop input is HIGH, the PUSH operation is enabled. This causes the stack pointer to increment and the file to be written with the required return linkage — the next microinstruction address following the subroutine jump which initiated the PUSH.

If the file enable input is LOW and the push/pop control is LOW, a POP operation occurs. This implies the usage of the return linkage during this cycle and thus a return from subroutine. The next LOW-to-HIGH clock transition causes the stack pointer to decrement. If the file enable is HIGH, no action is taken by the stack pointer regardless of any other input.

The stack pointer linkage is such that any combination of pushes, pops or stack references can be achieved. One microinstruction subroutines can be performed. Since the stack is 4 words deep, up to four microsubroutines can be nested.

The ZERO input is used to force the four outputs to the binary zero state. When the ZERO input is LOW, all Y outputs are LOW regardless of any other inputs (except  $\overline{OE}$ ). Each Y output bit also has a separate OR input such that a conditional logic one can be forced at each Y output. This allows jumping to different microinstructions on programmed conditions.

The Am2909/Am2911 feature three-state Y outputs. These can be particularly useful in military designs requiring external Ground Support Equipment (GSE) to provide automatic checkout of the microprocessor. The internal control can be placed in the high-impedance state, and preprogrammed sequences of microinstructions can be executed via external access to the control ROM/PROM.

2

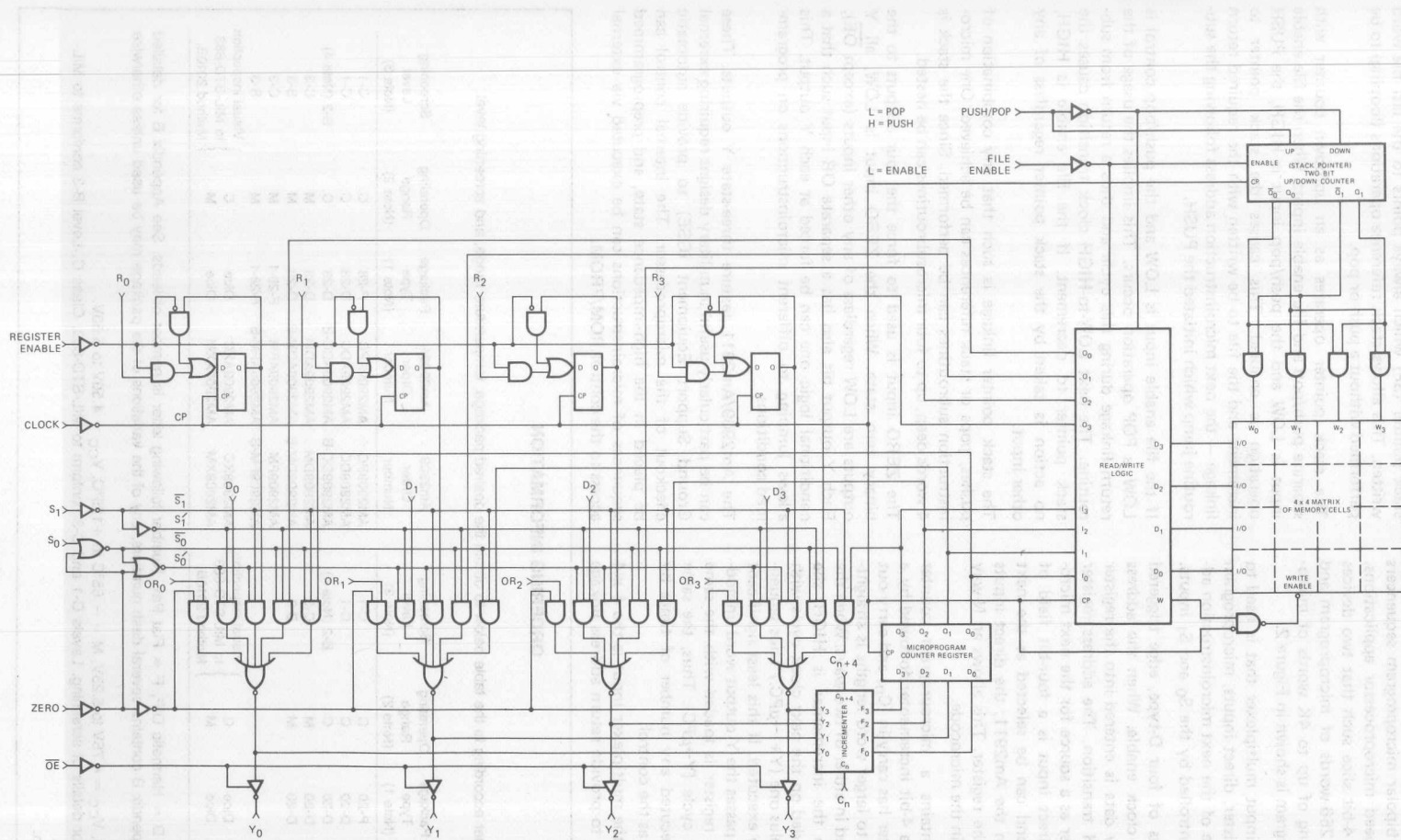
## ORDERING INFORMATION

Order the part number according to the table below to obtain the desired package, temperature range, and screening level.

| Am2911<br>Order<br>Number | Am2911A<br>Order<br>Number | Package<br>Type<br>(Note 1) | Operating<br>Range<br>(Note 2) | Screening<br>Level<br>(Note 3)                       | Am2909<br>Order<br>Number | Am2909A<br>Order<br>Number | Package<br>Type<br>(Note 1) | Operating<br>Range<br>(Note 2) | Screening<br>Level<br>(Note 3)                       |
|---------------------------|----------------------------|-----------------------------|--------------------------------|--|---------------------------|----------------------------|-----------------------------|--------------------------------|--|
| AM2911PC                  | AM2911APC                  | P-20                        | C                              | C-1  | AM2909PC                  | AM2909APC                  | P-28                        | C                              | C-1  |
| AM2911DC                  | AM2911ADC                  | D-20                        | C                              | C-1  | AM2909DC                  | AM2909ADC                  | D-28                        | C                              | C-1  |
| AM2911DC-B                | AM2911ADC-B                | D-20                        | C                              | B-2 (Note 4)   | AM2909DC-B                | AM2909ADC-B                | D-28                        | C                              | B-2 (Note 4)   |
| AM2911DM                  | AM2911ADM                  | D-20                        | M                              | C-3  | AM2909DM                  | AM2909ADM                  | D-28                        | M                              | C-3  |
| AM2911DM-B                | AM2911ADM-B                | D-20                        | M                              | B-3  | AM2909DM-B                | AM2909ADM-B                | D-28                        | M                              | B-3  |
|                           |                            |                             |                                |  | AM2909FM                  | AM2909AFM                  | F-28-1                      | M                              | C-3  |
|                           |                            |                             |                                |  | AM2909FM-B                | AM2909AFM-B                | F-28-1                      | M                              | B-3  |
| AM2911XC                  | AM2911AXC                  | Dice                        | C                              | Visual inspection<br>to MIL-STD-883<br>Method 2010B. | AM2909XC                  | AM2909AXC                  | Dice                        | C                              | Visual inspection<br>to MIL-STD-883<br>Method 2010B. |
| AM2911XM                  | AM2911AXM                  | Dice                        | M                              |  | AM2909XM                  | AM2909AXM                  | Dice                        | M                              |  |

- Notes: 1. P = Molded DIP, D = Hermetic DIP, F = Flat Pak. Number following letter is number of leads. See Appendix B for detailed outline. Where Appendix B contains several dash numbers, any of the variations of the package may be used unless otherwise specified.
2. C = 0°C to +70°C,  $V_{CC}$  = 4.75V to 5.25V, M = -55°C to +125°C,  $V_{CC}$  = 4.50V to 5.50V.
3. See Appendix A for details of screening. Levels C-1 and C-3 conform to MIL-STD-883, Class C. Level B-3 conforms to MIL-STD-883, Class B.
4. 96 hours of burn-in.

Figure 1.



Note:  $R_i$  and  $D_i$  connected together on Am2911 and  $OR_i$  removed.

**Figure 2. Microprogram Sequencer Block Diagram.**



# Am2910

## Microprogram Controller

### DISTINCTIVE CHARACTERISTICS

- Twelve Bits Wide  
Address up to 4096 words of microcode with one chip. All internal elements are a full 12 bits wide.
- Internal Loop Counter  
Pre-settable 12-bit down-counter for repeating instructions and counting loop iterations.
- Four Address Sources  
Microprogram Address may be selected from microprogram counter, branch address bus, 5-level push/pop stack, or internal holding register.
- Sixteen Powerful Microinstructions  
Executes 16 sequence control instructions, most of which are conditional on external condition input, state of internal loop counter, or both.
- Output Enable Controls for Three Branch Address Sources  
Built-in decoder function to enable external devices onto branch address bus. Eliminates external decoder.
- All Registers Positive Edge-triggered  
Simplifies timing problems. Eliminates long set-up times.
- Fast Control from Condition Input  
Delay from condition code input to address output only 21ns typical.

### GENERAL DESCRIPTION

The Am2910 Microprogram controller is an address sequencer intended for controlling the sequence of execution of microinstructions stored in microprogram memory. Besides the capability of sequential access, it provides conditional branching to any microinstruction within its 4096-microword range. A last-in, first-out stack provides microsubroutine return linkage and looping capability; there are five levels of nesting of microsubroutines. Microinstruction loop count control is provided with a count capacity of 4096.

During each microinstruction, the Microprogram controller provides a 12-bit address from one of four sources: 1) the microprogram address register ( $\mu$ PC), which usually contains an address one greater than the previous address; 2) an external (direct) input (D); 3) a register/counter (R) retaining data loaded during a previous microinstruction; or 4) a five-deep last-in, first-out stack (F).

For a detailed discussion of this architectural approach to microprogram control units, refer to "The Microprogramming Handbook", an AMD applications publication.

2

Am2910 BLOCK DIAGRAM

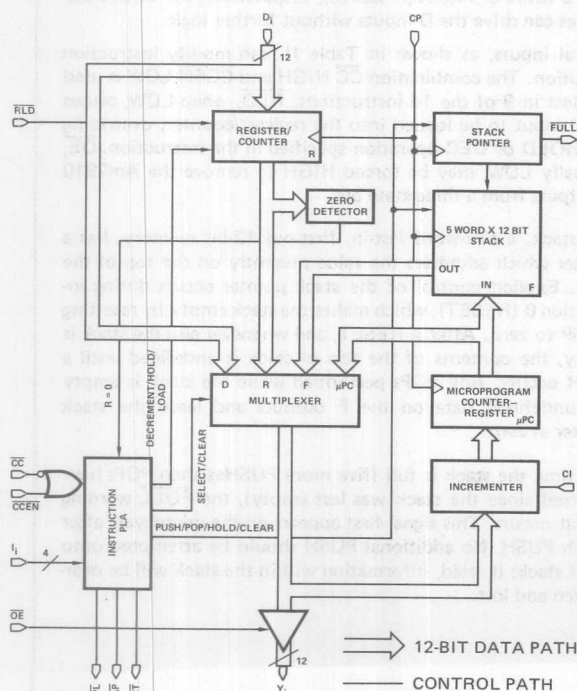


Figure 1.

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For applications information, see Chapter II of "Build a Microcomputer".

for use in high-speed microprocessor applications. It allows addressing of up to 4K words of microprogram. A block diagram is shown in Figure 1.

The controller contains a four-input multiplexer that is used to select either the register/counter, direct input, microprogram counter, or stack as the source of the next microinstruction address.

The register/counter consists of 12 D-type, edge-triggered flip-flops, with a common clock enable. When its load control,  $\overline{RLD}$ , is LOW, new data is loaded on a positive clock transition. A few instructions include load; in most systems, these instructions will be sufficient, simplifying the microcode. The output of the register/counter is available to the multiplexer as a source for the next microinstruction address. The direct input furnishes a source of data for loading the register/counter.

The Am2910 contains a microprogram counter ( $\mu PC$ ) that is composed of a 12-bit incrementer followed by a 12-bit register. The  $\mu PC$  can be used in either of two ways: When the carry-in to the incrementer is HIGH, the microprogram register is loaded on the next clock cycle with the current Y output word plus one ( $Y + 1 \rightarrow \mu PC$ ). Sequential microinstructions are thus executed. When the carry-in is LOW, the incrementer passes the Y output word unmodified so that  $\mu PC$  is reloaded with the same Y word on the next clock cycle ( $Y \rightarrow \mu PC$ ). The same microinstruction is thus executed any number of times.

The third source for the multiplexer is the direct (D) input. This source is used for branching.

The fourth source available at the multiplexer input is a 5-word by 12-bit stack (file). The stack is used to provide return address linkage when executing microsubroutines or loops. The stack contains a built-in stack pointer (SP) which always points to the last file word written. This allows stack reference operations (looping) to be performed without a pop.

The stack pointer operates as an up/down counter. During microinstructions 1, 4, and 5, the PUSH operation may occur. This causes the stack pointer to increment and the file to be written with the required return linkage. On the cycle following the PUSH, the return data is at the new location pointed to by the stack pointer.

During five microinstructions, a POP operation may occur. The stack pointer decrements at the next rising clock edge following a POP, effectively removing old information from the top of the stack.

The stack pointer linkage is such that any sequence of pushes, pops, or stack references can be achieved. At RESET (Instruction 0), the depth of nesting becomes zero. For each PUSH, the nesting depth increases by one; for each POP, the depth decreases by one. The depth can grow to five. After a depth of five is reached, FULL goes LOW. Any further PUSHes onto a full stack overwrite information at the top of the stack, but leave the stack pointer unchanged. This operation will usually destroy useful information and is normally avoided. A POP from an empty stack may place non-meaningful data on the Y outputs, but is otherwise safe. The stack pointer remains at zero whenever a POP is attempted from a stack already empty.

(8, 9, 15) as a 12-bit down counter, with result = zero available as a microinstruction branch test criterion. This provides efficient iteration of microinstructions. The register/counter is arranged such that if it is preloaded with a number N and then used as a loop termination counter, the sequence will be executed exactly N+1 times. During instruction 15, a three-way branch under combined control of the loop counter and the condition code is available.

The device provides three-state Y outputs. These can be particularly useful in designs requiring automatic checkout of the processor. The microprogram controller outputs can be forced into the high-impedance state, and pre-programmed sequences of microinstructions can be executed via external access to the address lines.

## OPERATION

Table I shows the result of each instruction in controlling the multiplexer which determines the Y outputs, and in controlling the three enable signals PL, MAP, and VECT. The effect on the register/counter and the stack after the next positive-going clock edge is also shown. The multiplexer determines which internal source drives the Y outputs. The value loaded into  $\mu PC$  is either identical to the Y output, or else one greater, as determined by CI. For each instruction, one and only one of the three outputs PL, MAP, and VECT is LOW. If these outputs control three-state enables for the primary source of microprogram jumps (usually part of a pipeline register), a PROM which maps the instruction to a microinstruction starting location, and an optional third source (often a vector from a DMA or interrupt source), respectively, the three-state sources can drive the D inputs without further logic.

Several inputs, as shown in Table II, can modify instruction execution. The combination  $\overline{CC}$  HIGH and  $\overline{CCEN}$  LOW is used as a test in 9 of the 16 instructions.  $\overline{RLD}$ , when LOW, causes the D input to be loaded into the register/counter, overriding any HOLD or DEC operation specified in the instruction.  $\overline{OE}$ , normally LOW, may be forced HIGH to remove the Am2910 Y outputs from a three-state bus.

The stack, a five-word last-in, first-out 12-bit memory, has a pointer which addresses the value presently on the top of the stack. Explicit control of the stack pointer occurs during instruction 0 (RESET), which makes the stack empty by resetting the SP to zero. After a RESET, and whenever else the stack is empty, the contents of the top of stack is undefined until a PUSH occurs. Any POPs performed while the stack is empty put undefined data on the F outputs and leave the stack pointer at zero.

Any time the stack is full (five more PUSHes than POPs have occurred since the stack was last empty), the FULL warning output occurs. This signal first appears on the microcycle after a fifth PUSH. No additional PUSH should be attempted onto a full stack; if tried, information within the stack will be overwritten and lost.

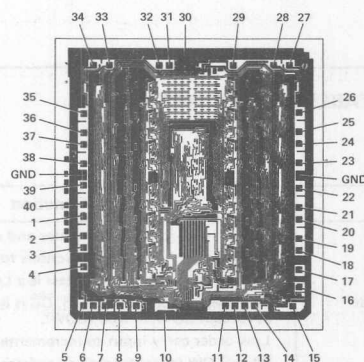
## ORDERING INFORMATION

Order the part number according to the table below to obtain the desired package, temperature range, and screening level.

| Order Number | Package Type<br>(Note 1) | Operating Range<br>(Note 2) | Screening Level<br>(Note 3)                          |
|--------------|--------------------------|-----------------------------|--|
| AM2910PC     | P-40                     | C                           | C-1  |
| AM2910DC     | D-40                     | C                           | C-1  |
| AM2910DC-B   | D-40                     | C                           | B-2 (Note 4)   |
| AM2910DM     | D-40                     | M                           | C-3  |
| AM2910DM-B   | D-40                     | M                           | B-3  |
| AM2910FM     | F-42                     | M                           | C-3  |
| AM2910FM-B   | F-42                     | M                           | B-3  |
| AM2910XC     | Dice                     | C                           | Visual inspection<br>to MIL-STD-883<br>Method 2010B. |
| AM2910XM     | Dice                     | M                           |  |

- Notes: 1. P = Molded DIP, D = Hermetic DIP, F = Flat Pak. Number following letter is number of leads. See Appendix B for detailed outline. Where Appendix B contains several dash numbers, any of the variations of the package may be used unless otherwise specified.
2. C = 0°C to +70°C,  $V_{CC}$  = 4.75V to 5.25V, M = -55°C to +125°C,  $V_{CC}$  = 4.50V to 5.50V.
3. See Appendix A for details of screening. Levels C-1 and C-3 conform to MIL-STD-883, Class C. Level B-3 conforms to MIL-STD-883, Class B.
4. 96 hour burn-in.

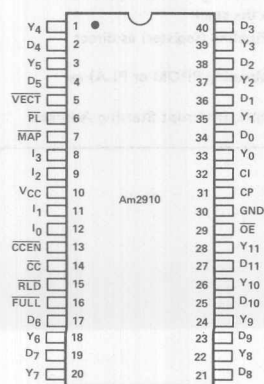
## Metallization and Pad Layout



Die Size 0.170" x 0.194"  
(Note: Numbers refer to DIP connections)

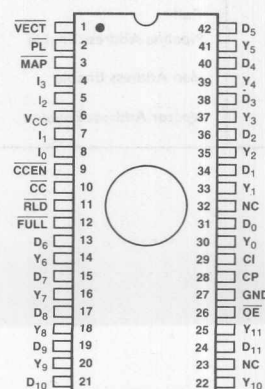
## CONNECTION DIAGRAMS — Top Views

## DIP



MPR-107

## Flat Package



MPR-108

Pin 1 is marked for orientation.

TABLE I. INSTRUCTIONS

| I <sub>3-10</sub> | MNEMONIC | NAME                  | REG/<br>CNTR<br>CON-<br>TENTS | FAIL                     |       | PASS                    |       | REG/<br>CNTR | ENABLE |
|-------------------|----------|-----------------------|-------------------------------|--------------------------|-------|-------------------------|-------|--------------|--------|
|                   |          |                       |                               | CCEN = LOW and CC = HIGH |       | CCEN = HIGH or CC = LOW |       |              |        |
|                   |          |                       |                               | Y                        | STACK | Y                       | STACK |              |        |
| 0                 | JZ       | JUMP ZERO             | X                             | 0                        | CLEAR | 0                       | CLEAR | HOLD         | PL     |
| 1                 | CJS      | COND JSB PL           | X                             | PC                       | HOLD  | D                       | PUSH  | HOLD         | PL     |
| 2                 | JMAP     | JUMP MAP              | X                             | D                        | HOLD  | D                       | HOLD  | HOLD         | MAP    |
| 3                 | CJP      | COND JUMP PL          | X                             | PC                       | HOLD  | D                       | HOLD  | HOLD         | PL     |
| 4                 | PUSH     | PUSH/COND LD CNTR     | X                             | PC                       | PUSH  | PC                      | PUSH  | Note 1       | PL     |
| 5                 | JSRP     | COND JSB R/PL         | X                             | R                        | PUSH  | D                       | PUSH  | HOLD         | PL     |
| 6                 | CJV      | COND JUMP VECTOR      | X                             | PC                       | HOLD  | D                       | HOLD  | HOLD         | VECT   |
| 7                 | JRP      | COND JUMP R/PL        | X                             | R                        | HOLD  | D                       | HOLD  | HOLD         | PL     |
| 8                 | RFCT     | REPEAT LOOP, CNTR ≠ 0 | ≠ 0                           | F                        | HOLD  | F                       | HOLD  | DEC          | PL     |
|                   |          |                       | = 0                           | PC                       | POP   | PC                      | POP   | HOLD         | PL     |
| 9                 | RPCT     | REPEAT PL, CNTR ≠ 0   | ≠ 0                           | D                        | HOLD  | D                       | HOLD  | DEC          | PL     |
|                   |          |                       | = 0                           | PC                       | HOLD  | PC                      | HOLD  | HOLD         | PL     |
| 10                | CRTN     | COND RTN              | X                             | PC                       | HOLD  | F                       | POP   | HOLD         | PL     |
| 11                | CJPP     | COND JUMP PL & POP    | X                             | PC                       | HOLD  | D                       | POP   | HOLD         | PL     |
| 12                | LDCT     | LD CNTR & CONTINUE    | X                             | PC                       | HOLD  | PC                      | HOLD  | LOAD         | PL     |
| 13                | LOOP     | TEST END LOOP         | X                             | F                        | HOLD  | PC                      | POP   | HOLD         | PL     |
| 14                | CONT     | CONTINUE              | X                             | PC                       | HOLD  | PC                      | HOLD  | HOLD         | PL     |
| 15                | TWB      | THREE-WAY BRANCH      | ≠ 0                           | F                        | HOLD  | PC                      | POP   | DEC          | PL     |
|                   |          |                       | = 0                           | D                        | POP   | PC                      | POP   | HOLD         | PL     |

Note 1: If  $\overline{\text{CCEN}}$  = LOW and  $\overline{\text{CC}}$  = HIGH, hold; else load. X = Don't Care

TABLE II. PIN FUNCTIONS

| Abbreviation             | Name                       | Function   |
|--------------------------|----------------------------|--|
| D <sub>i</sub>           | Direct Input Bit i         | Direct input to register/counter and multiplexer. D <sub>0</sub> is LSB  |
| I <sub>i</sub>           | Instruction Bit i          | Selects one-of-sixteen instructions for the Am2910   |
| CC                       | Condition Code             | Used as test criterion. Pass test is a LOW on $\overline{\text{CC}}$ .   |
| CCEN                     | Condition Code Enable      | Whenever the signal is HIGH, $\overline{\text{CC}}$ is ignored and the part operates as though $\overline{\text{CC}}$ were true (LOW). |
| CI                       | Carry-In                   | Low order carry input to incrementer for microprogram counter  |
| R $\overline{\text{LD}}$ | Register Load              | When LOW forces loading of register/counter regardless of instruction or condition   |
| $\overline{\text{OE}}$   | Output Enable              | Three-state control of Y <sub>i</sub> outputs  |
| CP                       | Clock Pulse                | Triggers all internal state changes at LOW-to-HIGH edge  |
| VCC                      | +5 Volts                   |  |
| GND                      | Ground                     |  |
| Y <sub>i</sub>           | Microprogram Address Bit i | Address to microprogram memory. Y <sub>0</sub> is LSB, Y <sub>11</sub> is MSB  |
| FULL                     | Full                       | Indicates that five items are on the stack   |
| PL                       | Pipeline Address Enable    | Can select #1 source (usually Pipeline Register) as direct input source  |
| MAP                      | Map Address Enable         | Can select #2 source (usually Mapping PROM or PLA) as direct input source  |
| VECT                     | Vector Address Enable      | Can select #3 source (for example, Interrupt Starting Address) as direct input source  |



## MAXIMUM RATINGS (Above which the useful life may be impaired)

|   |                        |
|---|------------------------|
| Storage Temperature                                 | -65°C to +150°C        |
| Temperature (Ambient) Under Bias                    | -55°C to +125°C        |
| Supply Voltage to Ground Potential                  | -0.5V to +7.0V         |
| DC Voltage Applied to Outputs for High Output State | -0.5V to $V_{CC}$ max. |
| DC Input Voltage                                    | -0.5V to +5.5V         |
| DC Output Current, Into Outputs                     | 30mA                   |
| DC Input Current                                    | -30mA to +5.0mA        |

## ELECTRICAL CHARACTERISTICS The Following Conditions Apply Unless Otherwise Specified:

COM'L  $T_A = 0^\circ\text{C}$  to  $+70^\circ\text{C}$   $V_{CC} = 5.0\text{V} \pm 5\%$  MIN. = 4.75V MAX. = 5.25VMIL  $T_C = -55^\circ\text{C}$  to  $+125^\circ\text{C}$   $V_{CC} = 5.0\text{V} \pm 10\%$  MIN. = 4.50V MAX. = 5.50V

## DC CHARACTERISTICS OVER OPERATING RANGE

| Parameters | Description                           | Test Conditions (Note 1)   | Min. | Typ.<br>(Note 2) | Max.  | Units         |
|------------|---------------------------------------|--|------|------------------|-------|---------------|
| $V_{OH}$   | Output HIGH Voltage                   | $V_{CC} = \text{MIN.}$ , $I_{OH} = -1.6\text{mA}$<br>$V_{IN} = V_{IH}$ or $V_{IL}$ | 2.4  |                  |       | Volts         |
| $V_{OL}$   | Output LOW Voltage                    | $V_{CC} = \text{MIN.}$<br>$V_{IN} = V_{IH}$ or $V_{IL}$                            |      |                  | 0.5   | Volts         |
|            |                                       | $Y_0-11$ , $I_{OL} = 12\text{mA}$<br>$PL, VECT, MAP, FULL$ , $I_{OL} = 8\text{mA}$ |      |                  |       |               |
| $V_{IH}$   | Input HIGH Level (Note 4)             | Guaranteed Input Logical HIGH voltage for all inputs                               | 2.0  |                  |       | Volts         |
| $V_{IL}$   | Input LOW Level (Note 4)              | Guaranteed input logical LOW voltage for all inputs                                |      |                  | 0.8   | Volts         |
| $V_I$      | Input Clamp Voltage                   | $V_{CC} = \text{MIN.}$ , $I_{IN} = -18\text{mA}$                                   |      |                  | -1.5  | Volts         |
| $I_{IL}$   | Input LOW Current                     | $V_{CC} = \text{MAX.}$ , $V_{IN} = 0.5\text{V}$                                    |      |                  | -0.87 | mA            |
|            |                                       | $D_0-11$   |      |                  | -0.54 |               |
|            |                                       | $CI, CCEN$   |      |                  | -0.72 |               |
|            |                                       | $I_0-3, OE, RLD$   |      |                  | -1.31 |               |
|            |                                       | $\overline{CC}$  |      |                  | -2.14 |               |
|            |                                       | CP   |      |                  |       |               |
| $I_{IH}$   | Input HIGH Current                    | $V_{CC} = \text{MAX.}$ , $V_{IN} = 2.7\text{V}$                                    |      |                  | 80    | $\mu\text{A}$ |
|            |                                       | $D_0-11$   |      |                  | 30    |               |
|            |                                       | $CI, CCEN$   |      |                  | 40    |               |
|            |                                       | $I_0-3, OE, RLD$   |      |                  | 50    |               |
|            |                                       | $\overline{CC}$  |      |                  | 100   |               |
|            |                                       | CP   |      |                  |       |               |
| $I_I$      | Input HIGH Current                    | $V_{CC} = \text{MAX.}$ , $V_{IN} = 5.5\text{V}$                                    |      |                  | 1.0   | mA            |
| $I_{SC}$   | Output Short Circuit Current (Note 3) | $V_{CC} = \text{MAX.}$   | -30  |                  | -85   | mA            |
| $I_{OZL}$  | Output OFF Current                    | $V_{CC} = \text{MAX.}$   |      |                  | -50   | $\mu\text{A}$ |
| $I_{OZH}$  |                                       | $OE = 2.4\text{V}$   |      |                  | 50    |               |
| $I_{CC}$   | Power Supply Current                  | $V_{CC} = \text{MAX.}$   |      | 195              | 320   | mA            |
|            |                                       | Am2910PC, DC   |      |                  | 344   |               |
|            |                                       | $T_A = 0^\circ\text{C}$ to $+70^\circ\text{C}$                                     |      |                  | 280   |               |
|            |                                       | $T_A = +70^\circ\text{C}$  |      |                  | 340   |               |
|            |                                       | $T_C = -55^\circ\text{C}$ to $+125^\circ\text{C}$                                  |      |                  | 227   |               |
|            |                                       | $T_C = +125^\circ\text{C}$   |      |                  |       |               |

Notes: 1. For conditions shown as MIN. or MAX., use the appropriate value specified under Electrical Characteristics for the applicable device type.

2. Typical limits are at  $V_{CC} = 5.0\text{V}$ ,  $25^\circ\text{C}$  ambient and maximum loading.

3. Not more than one output should be shorted at a time. Duration of the short circuit test should not exceed one second.

4. These input levels provide no guaranteed noise immunity and should only be tested in a static-, noise-free environment.

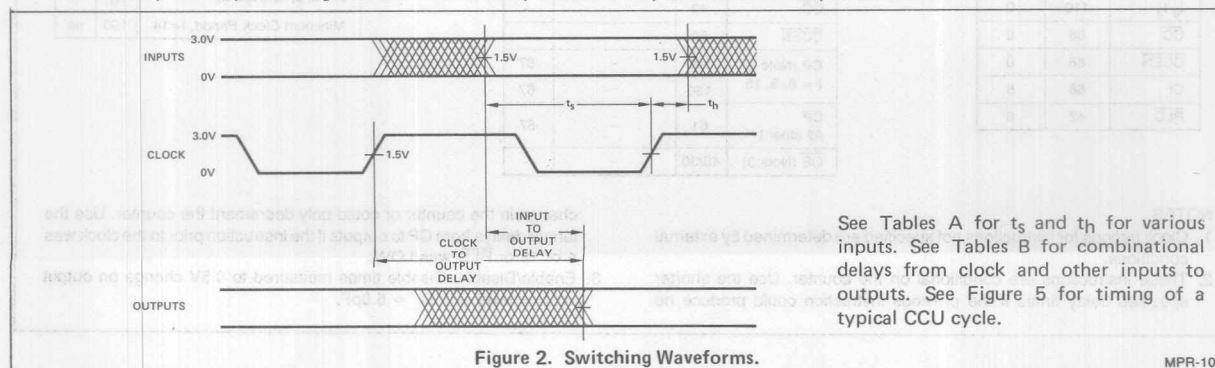


Figure 2. Switching Waveforms.

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## Am2910 SWITCHING CHARACTERISTICS

The tables below define the Am2910 switching characteristics. Tables A are set-up and hold times relative to the clock LOW-to-HIGH transition. Tables B are combinational delays. Tables C are clock requirements. All measurements are made at 1.5V with input levels at 0V or 3V. All values are in ns. All outputs have maximum DC loading.

### I. TYPICAL ROOM TEMPERATURE CHARACTERISTICS ( $T_A = 25^\circ\text{C}$ , $V_{CC} = 5.0\text{V}$ , $C_L = 50\text{pF}$ )

#### A. Set-up and Hold Times

| Input                | $t_s$ | $t_h$ |
|----------------------|-------|-------|
| $D_1 \rightarrow R$  | 9     | 4     |
| $D_1 \rightarrow PC$ | 34    | 3     |
| $I_0 \cdot I_3$      | 64    | 0     |
| $\overline{CC}$      | 46    | 0     |
| $\overline{CCEN}$    | 49    | 0     |
| $CI$                 | 26    | 2     |
| $RLD$                | 18    | 2     |

#### B. Combinational Delays

| Input                    | Y     | PL, VECT, MAP | Full |
|--------------------------|-------|---------------|------|
| $D_0 \cdot D_{11}$       | 14    | —             | —    |
| $I_0 \cdot I_3$          | 40    | 27            | —    |
| $\overline{CC}$          | 21    | —             | —    |
| $\overline{CCEN}$        | 23    | —             | —    |
| CP (Note 2)              | 54    | —             | 29   |
| I = 8, 9, 15             | 79    | —             | 29   |
| CP                       | 26    | —             | 29   |
| All other I              | —     | —             | —    |
| $\overline{OE}$ (Note 3) | 25/24 | —             | —    |

#### C. Clock Requirements (Note 1)

|  |    |    |
|--|----|----|
| Minimum Clock LOW Time                         | 30 | ns |
| Minimum Clock HIGH Time                        | 30 | ns |
| Minimum Clock Period,<br>I = 8, 9, 15 (Note 2) | 74 | ns |
|  | 99 | ns |
| Minimum Clock Period, I = 14                   | 60 | ns |

### II. GUARANTEED CHARACTERISTICS OVER COMMERCIAL OPERATING RANGE

Am2910PC,DC ( $T_A = 0^\circ\text{C}$  to  $+70^\circ\text{C}$ ,  $V_{CC} = 4.75\text{V}$  to  $5.25\text{V}$ ,  $C_L = 50\text{pF}$ )

#### A. Set-up and Hold Times

| Input                | $t_s$ | $t_h$ |
|----------------------|-------|-------|
| $D_1 \rightarrow R$  | 24    | 6     |
| $D_1 \rightarrow PC$ | 58    | 4     |
| $I_0 \cdot I_3$      | 104   | 0     |
| $\overline{CC}$      | 80    | 0     |
| $\overline{CCEN}$    | 80    | 0     |
| $CI$                 | 46    | 5     |
| $RLD$                | 36    | 6     |

#### B. Combinational Delays

| Input                    | Y     | PL, VECT, MAP | Full |
|--------------------------|-------|---------------|------|
| $D_0 \cdot D_{11}$       | 20    | —             | —    |
| $I_0 \cdot I_3$          | 70    | 51            | —    |
| $\overline{CC}$          | 43    | —             | —    |
| $\overline{CCEN}$        | 45    | —             | —    |
| CP (Note 2)              | 100   | —             | 60   |
| I = 8, 9, 15             | 125   | —             | 60   |
| CP                       | 55    | —             | 60   |
| All other I              | —     | —             | —    |
| $\overline{OE}$ (Note 3) | 35/30 | —             | —    |

#### C. Clock Requirements (Note 1)

|  |     |    |
|--|-----|----|
| Minimum Clock LOW Time                         | 50  | ns |
| Minimum Clock HIGH Time                        | 35  | ns |
| Minimum Clock Period,<br>I = 8, 9, 15 (Note 2) | 138 | ns |
|  | 163 | ns |
| Minimum Clock Period, I = 14                   | 93  | ns |

### III. GUARANTEED CHARACTERISTICS OVER MILITARY OPERATING RANGE

Am2910DM,FM ( $T_C = -55^\circ\text{C}$  to  $+125^\circ\text{C}$ ,  $V_{CC} = 4.5\text{V}$  to  $5.5\text{V}$ ,  $C_L = 50\text{pF}$ )

#### A. Set-up and Hold Times

| Input                | $t_s$ | $t_h$ |
|----------------------|-------|-------|
| $D_1 \rightarrow R$  | 28    | 6     |
| $D_1 \rightarrow PC$ | 62    | 4     |
| $I_0 \cdot I_3$      | 110   | 0     |
| $\overline{CC}$      | 86    | 0     |
| $\overline{CCEN}$    | 86    | 0     |
| $CI$                 | 58    | 5     |
| $RLD$                | 42    | 6     |

#### B. Combinational Delays

| Input                    | Y     | PL, VECT, MAP | Full |
|--------------------------|-------|---------------|------|
| $D_0 \cdot D_{11}$       | 25    | —             | —    |
| $I_0 \cdot I_3$          | 75    | 58            | —    |
| $\overline{CC}$          | 48    | —             | —    |
| $\overline{CCEN}$        | 50    | —             | —    |
| CP (Note 2)              | 106   | —             | 67   |
| I = 8, 9, 15             | 130   | —             | 67   |
| CP                       | 61    | —             | 67   |
| All other I              | —     | —             | —    |
| $\overline{OE}$ (Note 3) | 40/30 | —             | —    |

#### C. Clock Requirements (Note 1)

|  |     |    |
|--|-----|----|
| Minimum Clock LOW Time                         | 58  | ns |
| Minimum Clock HIGH Time                        | 42  | ns |
| Minimum Clock Period,<br>I = 8, 9, 15 (Note 2) | 143 | ns |
|  | 167 | ns |
| Minimum Clock Period, I = 14                   | 100 | ns |

#### NOTES:

1. Clock periods for instructions not specified are determined by external conditions.
2. These instructions are conditional on the counter. Use the shorter specified delay times if the previous instruction could produce no

change in the counter or could only decrement the counter. Use the longer delays from CP to outputs if the instruction prior to the clock was 4 or 12 or RLD was LOW.

3. Enable/Disable. Disable times measured to 0.5V change on output voltage level with  $C_L = 50\text{pF}$ .

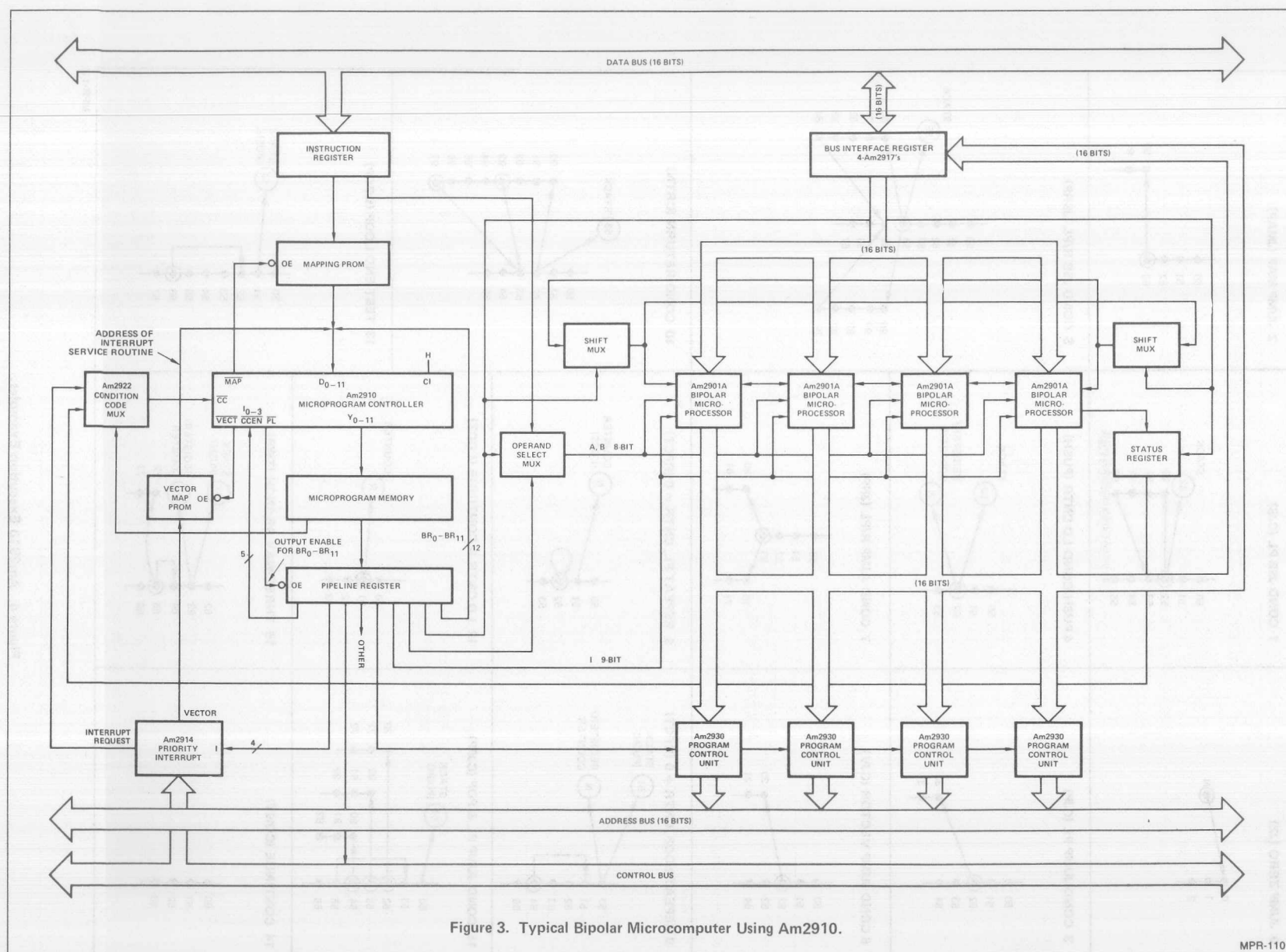
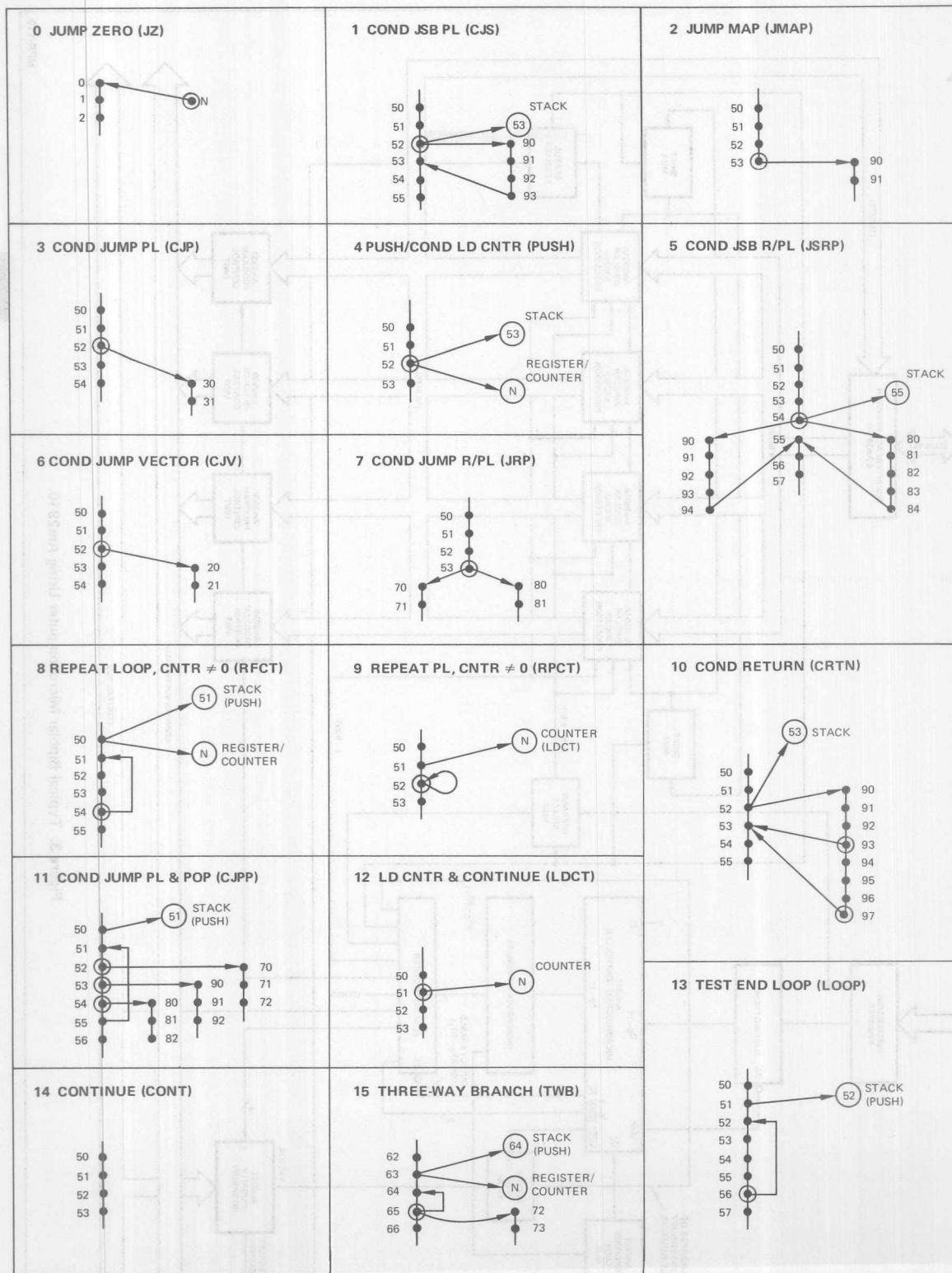


Figure 3. Typical Bipolar Microcomputer Using Am2910.

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Figure 4. Am2910 Execution Examples.



## THE Am2910 INSTRUCTION SET

The Am2910 provides 16 instructions which select the address of the next microinstruction to be executed. Four of the instructions are unconditional — their effect depends only on the instruction. Ten of the instructions have an effect which is partially controlled by an external, data-dependent condition. Three of the instructions have an effect which is partially controlled by the contents of the internal register/counter. The instruction set is shown in Table I. In this discussion it is assumed that  $C_n$  is tied HIGH.

In the ten conditional instructions, the result of the data-dependent test is applied to  $\overline{CC}$ . If the  $\overline{CC}$  input is LOW, the test is considered to have been passed, and the action specified in the name occurs; otherwise, the test has failed and an alternate (often simply the execution of the next sequential microinstruction) occurs. Testing of  $\overline{CC}$  may be disabled for a specific microinstruction by setting  $\overline{CCEN}$  HIGH, which unconditionally forces the action specified in the name; that is, it forces a pass. Other ways of using  $\overline{CCEN}$  include (1) tying it HIGH, which is useful if no microinstruction is data-dependent; (2) tying it LOW if data-dependent instructions are never forced unconditionally; or (3) tying it to the source of Am2910 instruction bit 10, which leaves instructions 4, 6, and 10 as data-dependent but makes others unconditional. All of these tricks save one bit of microcode width.

The effect of three instructions depends on the contents of the register/counter. Unless the counter holds a value of zero, it is decremented; if it does hold zero, it is held and a different microprogram next address is selected. These instructions are useful for executing a microinstruction loop a known number of times. Instruction 15 is affected both by the external condition code and the internal register/counter.

Perhaps the best technique for understanding the Am2910 is to simply take each instruction and review its operation. In order to provide some feel for the actual execution of these instructions, Figure 4 is included and depicts examples of all 16 instructions.

The examples given in Figure 4 should be interpreted in the following manner: The intent is to show microprogram flow as various microprogram memory words are executed. For example, the CONTINUE instruction, instruction number 14, as shown in Figure 4, simply means that the contents of microprogram memory word 50 is executed, then the contents of word 51 is executed. This is followed by the contents of microprogram memory word 52 and the contents of microprogram memory word 53. The microprogram addresses used in the examples were arbitrarily chosen and have no meaning other than to show instruction flow. The exception to this is the first example, JUMP ZERO, which forces the microprogram location counter to address ZERO. Each dot refers to the time that the contents of the microprogram memory word is in the pipeline register. While no special symbology is used for the conditional instructions, the text to follow will explain what the conditional choices are in each example.

It might be appropriate at this time to mention that AMD has a microprogram assembler called AMDASM, which has the capability of using the Am2910 instructions in symbolic representation. AMDASM's Am2910 instruction symbolics (or mnemonics) are given in Figure 4 for each instruction and are also shown in Table I.

Instruction 0, JZ (JUMP and ZERO, or RESET) unconditionally specifies that the address of the next microinstruction is zero. Many designs use this feature for power-up sequences

and provide the power-up firmware beginning at microprogram memory word location 0.

Instruction 1 is a CONDITIONAL JUMP-TO-SUBROUTINE via the address provided in the pipeline register. As shown in Figure 4, the machine might have executed words at address 50, 51, and 52. When the contents of address 52 is in the pipeline register, the next address control function is the CONDITIONAL JUMP-TO-SUBROUTINE. Here, if the test is passed, the next instruction executed will be the contents of microprogram memory location 90. If the test has failed, the JUMP-TO-SUBROUTINE will not be executed; the contents of microprogram memory location 53 will be executed instead. Thus, the CONDITIONAL JUMP-TO-SUBROUTINE instruction at location 52 will cause the instruction either in location 90 or in location 53 to be executed next. If the TEST input is such that location 90 is selected, value 53 will be pushed onto the internal stack. This provides the return linkage for the machine when the subroutine beginning at location 90 is completed. In this example, the subroutine was completed at location 93 and a RETURN-FROM-SUBROUTINE would be found at location 93.

Instruction 2 is the JUMP MAP instruction. This is an unconditional instruction which causes the  $\overline{MAP}$  output to be enabled so that the next microinstruction location is determined by the address supplied via the mapping PROMs. Normally, the JUMP MAP instruction is used at the end of the instruction fetch sequence for the machine. In the example of Figure 4, microinstructions at locations 50, 51, 52, and 53 might have been the fetch sequence and at its completion at location 53, the jump map function would be contained in the pipeline register. This example shows the mapping PROM outputs to be 90; therefore, an unconditional jump to microprogram memory address 90 is performed.

Instruction 3, CONDITIONAL JUMP PIPELINE, derives its branch address from the pipeline register branch address value ( $BR_0 - BR_{11}$  in Figure 2). This instruction provides a technique for branching to various microprogram sequences depending upon the test condition inputs. Quite often, state machines are designed which simply execute tests on various inputs waiting for the condition to come true. When the true condition is reached, the machine then branches and executes a set of microinstructions to perform some function. This usually has the effect of resetting the input being tested until some point in the future. Figure 4 shows the conditional jump via the pipeline register address at location 52. When the contents of microprogram memory word 52 are in the pipeline register, the next address will be either location 53 or location 30 in this example. If the test is passed, the value currently in the pipeline register (3) will be selected. If the test fails, the next address selected will be contained in the microprogram counter which, in this example, is 53.

Instruction 4 is the PUSH/CONDITIONAL LOAD COUNTER instruction and is used primarily for setting up loops in microprogram firmware. In Figure 4, when instruction 52 is in the pipeline register, a PUSH will be made onto the stack and the counter will be loaded based on the condition. When a PUSH occurs, the value pushed is always the next sequential instruction address. In this case, the address is 53. If the test fails, the counter is not loaded; if it is passed, the counter is loaded with the value contained in the pipeline register branch address field. Thus, a single microinstruction can be used to set up a loop to be executed a specific number of times. Instruction 8 will

## THE Am2910 INSTRUCTION SET (Cont.)

describe how to use the pushed value and the register/counter for looping.

Instruction 5 is a **CONDITIONAL JUMP-TO-SUBROUTINE** via the register/counter or the contents of the PIPELINE register. As shown in Figure 4, a PUSH is always performed and one of two subroutines executed. In this example, either the subroutine beginning at address 80 or the subroutine beginning at address 90 will be performed. A return-from-subroutine (instruction number 10) returns the microprogram flow to address 55. In order for this microinstruction control sequence to operate correctly, both the next address fields of instruction 53 and the next address fields of instruction 54 would have to contain the proper value. Let's assume that the branch address fields of instruction 53 contain the value 90 so that it will be in the Am2910 register/counter when the contents of address 54 are in the pipeline register. This requires that the instruction at address 53 load the register/counter. Now, during the execution of instruction 5 (at address 54), if the test failed, the contents of the register (value = 90) will select the address of the next microinstruction. If the test input passes, the pipeline register contents (value = 80) will determine the address of the next microinstruction. Therefore, this instruction provides the ability to select one of two subroutines to be executed based on a test condition.

Instruction 6 is a **CONDITIONAL JUMP VECTOR** instruction which provides the capability to take the branch address from a third source heretofore not discussed. In order for this instruction to be useful, the Am2910 output, **VECT** is used to control a three-state control input of a register, buffer, or PROM containing the next microprogram address. This instruction provides one technique for performing interrupt type branching at the microprogram level. Since this instruction is conditional, a pass causes the next address to be taken from the vector source, while failure causes the next address to be taken from the microprogram counter. In the example of Figure 4, if the **CONDITIONAL JUMP VECTOR** instruction is contained at location 52, execution will continue at vector address 20 if the **CC** input is LOW and the microinstruction at address 53 will be executed if the **CC** input is HIGH.

Instruction 7 is a **CONDITIONAL JUMP** via the contents of the Am2910 REGISTER/COUNTER or the contents of the PIPELINE register. This instruction is very similar to instruction 5; the conditional jump-to-subroutine via R or PL. The major difference between instruction 5 and instruction 7 is that no push onto the stack is performed with 7. Figure 4 depicts this instruction as a branch to one of two locations depending on the test condition. The example assumes the pipeline register contains the value 70 when the contents of address 52 is being executed. As the contents of address 53 is clocked into the pipeline register, the value 70 is loaded into the register/counter in the Am2910. The value 80 is available when the contents of address 53 is in the pipeline register. Thus, control is transferred to either address 70 or address 80 depending on the test condition.

Instruction 8 is the **REPEAT LOOP, COUNTER  $\neq$  ZERO** instruction. This microinstruction makes use of the decrementing capability of the register/counter. To be useful, some previous instruction, such as 4, must have loaded a count value into the register/counter. This instruction checks to see whether the register/counter contains a non-zero value. If so, the register/counter is decremented, and the address of the next microinstruction is taken from the top of the stack. If the register counter contains zero, the loop exit condition is occurring; control falls through to the next sequential microinstruction

by selecting  $\mu$ PC; the stack is POP'd by decrementing the stack pointer, but the contents of the top of the stack are thrown away.

An example of the **REPEAT LOOP, COUNTER  $\neq$  ZERO** instruction is shown in Figure 4. In this example, location 50 most likely would contain a **PUSH/CONDITIONAL LOAD COUNTER** instruction which would have caused address 51 to be PUSHed on the stack and the counter to be loaded with the proper value for looping the desired number of times.

In this example, since the loop test is made at the end of the instructions to be repeated (microaddress 54), the proper value to be loaded by the instructions at address 50 is one less than the desired number of passes through the loop. This method allows a loop to be executed 1 to 4096 times. If it is desired to execute the loop from 0 to 4095 times, the firmware should be written to make the loop exit test immediately after loop entry.

Single-microinstruction loops provide a highly efficient capability for executing a specific microinstruction a fixed number of times. Examples include fixed rotates, byte swap, fixed point multiply, and fixed point divide.

Instruction 9 is the **REPEAT PIPELINE REGISTER, COUNTER  $\neq$  ZERO** instruction. This instruction is similar to instruction 8 except that the branch address now comes from the pipeline register rather than the file. In some cases, this instruction may be thought of as a one-word file extension; that is, by using this instruction, a loop with the counter can still be performed when subroutines are nested five deep. This instruction's operation is very similar to that of instruction 8. The differences are that on this instruction, a failed test condition causes the source of the next microinstruction address to be the D inputs; and, when the test condition is passed, this instruction does not perform a POP because the stack is not being used.

In the example of Figure 4, the **REPEAT PIPELINE, COUNTER  $\neq$  ZERO** instruction is instruction 52 and is shown as a single microinstruction loop. The address in the pipeline register would be 52. Instruction 51 in this example could be the **LOAD COUNTER AND CONTINUE** instruction (number 12). While the example shows a single microinstruction loop, by simply changing the address in a pipeline register, multi-instruction loops can be performed in this manner for a fixed number of times as determined by the counter.

Instruction 10 is the **conditional RETURN-FROM-SUBROUTINE** instruction. As the name implies, this instruction is used to branch from the subroutine back to the next microinstruction address following the subroutine call. Since this instruction is conditional, the return is performed only if the test is passed. If the test is failed, the next sequential microinstruction is performed. The example in Figure 4 depicts the use of the conditional **RETURN-FROM-SUBROUTINE** instruction in both the conditional and the unconditional modes. This example first shows a jump-to-subroutine at instruction location 52 where control is transferred to location 90. At location 93, a conditional **RETURN-FROM-SUBROUTINE** instruction is performed. If the test is passed, the stack is accessed and the program will transfer to the next instruction at address 53. If the test is failed, the next microinstruction at address 94 will be executed. The program will continue to address 97 where the subroutine is complete. To perform an unconditional **RETURN-FROM-SUBROUTINE**, the conditional **RETURN-FROM-SUBROUTINE** instruction is executed unconditionally; the microinstruction at address 97 is programmed to force

## THE Am2910 INSTRUCTION SET (Cont.)

$\overline{CCEN}$  HIGH, disabling the test and the forced PASS causes an unconditional return.

Instruction 11 is the CONDITIONAL JUMP PIPELINE register address and POP stack instruction. This instruction provides another technique for loop termination and stack maintenance. The example in Figure 4 shows a loop being performed from address 55 back to address 51. The instructions at locations 52, 53, and 54 are all conditional JUMP and POP instructions. At address 52, if the  $\overline{CC}$  input is LOW, a branch will be made to address 70 and the stack will be properly maintained via a POP. Should the test fail, the instruction at location 53 (the next sequential instruction) will be executed. Likewise, at address 53, either the instruction at 90 or 54 will be subsequently executed, respective to the test being passed or failed. The instruction at 54 follows the same rules, going to either 80 or 55. An instruction sequence as described here, using the CONDITIONAL JUMP PIPELINE and POP instruction, is very useful when several inputs are being tested and the microprogram is looping waiting for any of the inputs being tested to occur before proceeding to another sequence of instructions. This provides the powerful jump-table programming technique at the firmware level.

Instruction 12 is the LOAD COUNTER AND CONTINUE instruction, which simply enables the counter to be loaded with the value at its parallel inputs. These inputs are normally connected to the pipeline branch address field which (in the architecture being described here) serves to supply either a branch address or a counter value depending upon the microinstruction being executed. There are altogether three ways of loading the counter — the explicit load by this instruction 12; the conditional load included as part of instruction 4; and the use of the  $\overline{RLD}$  input along with any instruction. The use of  $\overline{RLD}$  with any instruction overrides any counting or decrementation specified in the instruction, calling for a load instead. Its use provides additional microinstruction power, at the expense of one bit of microinstruction width. This instruction 12 is exactly equivalent to the combination of instruction 14 and  $\overline{RLD}$  LOW. Its purpose is to provide a simple capability to load the register/counter in those implementations which do not provide microprogrammed control for  $\overline{RLD}$ .

Instruction 13 is the TEST END-OF-LOOP instruction, which provides the capability of conditionally exiting a loop at the bottom; that is this is a conditional instruction that will cause the microprogram to loop, via the file, if the test is failed else to continue to the next sequential instruction. The example in Figure 4 shows the TEST END-OF-LOOP microinstruction at address 56. If the test fails, the microprogram will branch to address 52. Address 52 is on the stack because a PUSH instruction had been executed at address 51. If the test is passed at instruction 56, the loop is terminated and the next sequential microinstruction at address 57 is executed, which also causes the stack to be POP'd; thus, accomplishing the required stack maintenance.

Instruction 14 is the CONTINUE instruction, which simply causes the microprogram counter to increment so that the next sequential microinstruction is executed. This is the simplest microinstruction of all and should be the default instruction which the firmware requests whenever there is nothing better to do.

Instruction 15, THREE-WAY BRANCH, is the most complex. It provides for testing of both a data-dependent condition and the counter during one microinstruction and provides for selecting among one of three microinstruction addresses as the next microinstruction to be performed. Like instruction 8, a previous instruction will have loaded a count into the register/counter while pushing a microbranch address onto the stack. Instruction 15 performs a decrement-and-branch-until-zero function similar to instruction 8. The next address is taken from the top of the stack until the count reaches zero; then the next address comes from the pipeline register. The above action continues as long as the test condition fails. If at any execution of instruction 15 the test condition is passed, no branch is taken; the microprogram counter register furnishes the next address. When the loop is ended, either by the count becoming zero, or by passing the conditional test, the stack is POP'd by decrementing the stack pointer, since interest in the value contained at the top of the stack is then complete.

The application of instruction 15 can enhance performance of a variety of machine-level instructions. For instance, (1) a memory search instruction to be terminated either by finding a desired memory content or by reaching the search limit; (2) variable-field-length arithmetic terminated early upon finding that the content of the portion of the field still unprocessed is all zeroes; (3) key search in a disc controller processing variable length records; (4) normalization of a floating point number.

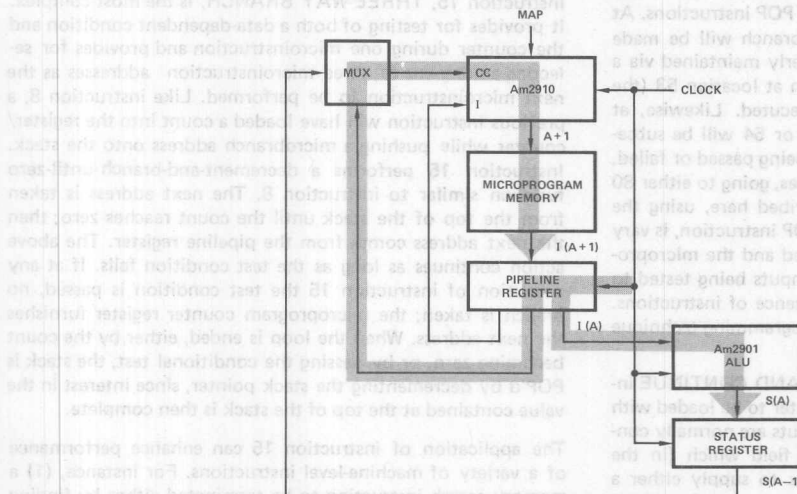
As one example, consider the case of a memory search instruction. As shown in Figure 4, the instruction at microprogram address 63 can be Instruction 4 (PUSH), which will push the value 64 onto the microprogram stack and load the number N, which is one less than the number of memory locations to be searched before giving up. Location 64 contains a microinstruction which fetches the next operand from the memory area to be searched and compares it with the search key. Location 65 contains a microinstruction which tests the result of the comparison and also is a THREE-WAY BRANCH for microprogram control. If no match is found, the test fails and the microprogram goes back to location 64 for the next operand address. When the count becomes zero, the microprogram branches to location 72, which does whatever is necessary if no match is found. If a match occurs on any execution of the THREE-WAY BRANCH at location 65, control falls through to location 66 which handles this case. Whether the instruction ends by finding a match or not, the stack will have been POP'd once, removing the value 64 from the top of the stack.



## ARCHITECTURES USING THE Am2910

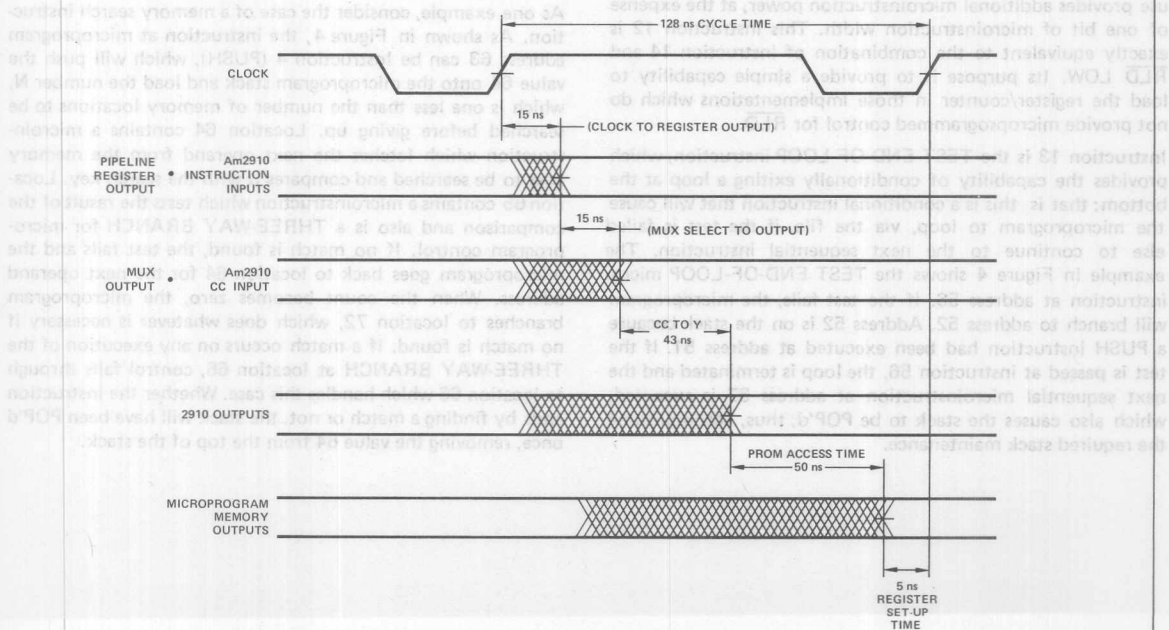
(Shading shows path(s) which usually limit speed)

Figure 5.

One Level Pipeline Based  
(Recommended)

One level pipeline provides better speed than most other architectures. The  $\mu$ Program Memory and the Am2901 array are in parallel speed paths instead of in series. This is the recommended architecture for Am2900 designs.

MPR-112



Typical CCU Cycle Timing Waveforms.

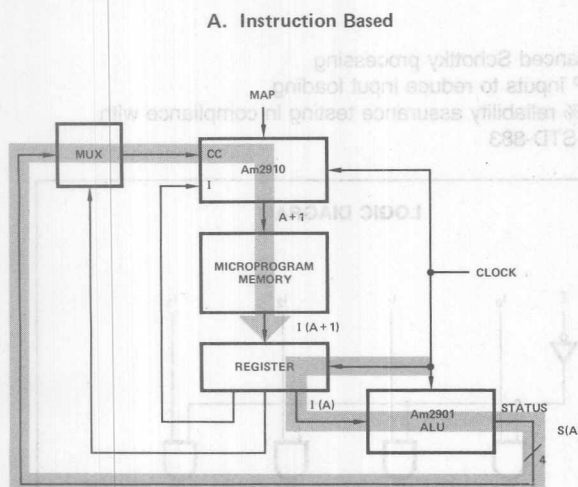
This drawing shows the timing relationships in the CCU illustrated above.

MPR-113



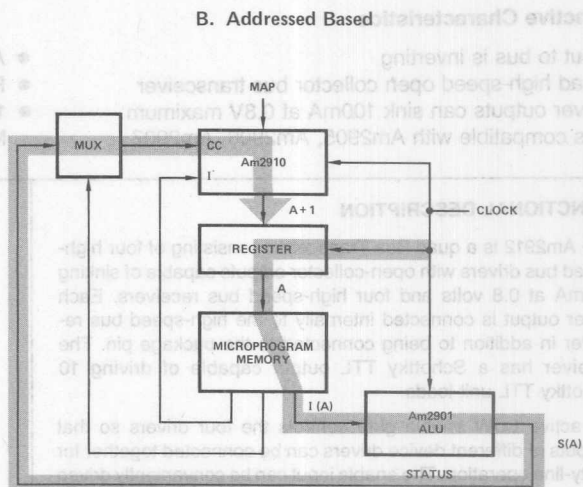
(Shading shows path(s) which usually limit speed)

**Figure 6.**



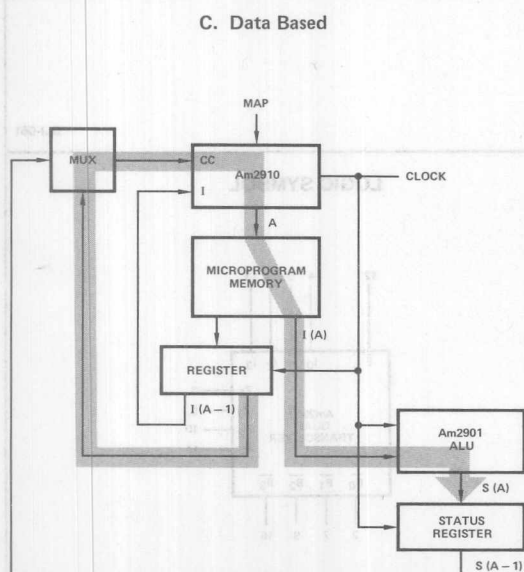
A Register at the Microprogram Memory output contains the microinstruction being executed. The microprogram memory and Am2901 delay are in series. Conditional branches are executed on same cycle as the ALU operation generating the condition.

MPR-114



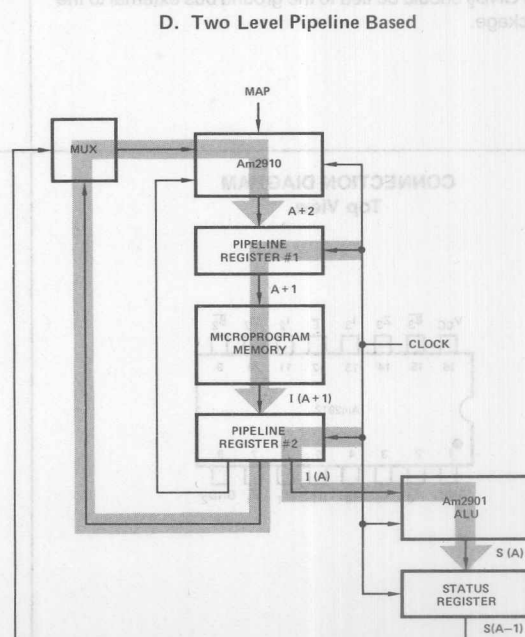
The Register at the Am2910 output contains the address of the microinstruction being executed. The Microprogram Memory and Am2901 are in series in the critical path. This architecture provides about the same speed as the Instruction based architecture, but requires fewer register bits, since only the address (typically 10-12 bits) is stored instead of the instruction (typically 40-60 bits).

MPR-115



The Status Register provides conditional Branch control based on results of previous ALU cycle. The Microprogram Memory and Am2901 are in series in the critical paths.

MPR-116



Two level pipeline provides highest possible speed. It is more difficult to program because the selection of a microinstruction occurs two instructions ahead of its execution.

MPR-117

## Distinctive Characteristics

- Input to bus is inverting
- Quad high-speed open collector bus transceiver
- Driver outputs can sink 100mA at 0.8V maximum
- Bus compatible with Am2905, Am2906, Am2907
- Advanced Schottky processing
- PNP inputs to reduce input loading
- 100% reliability assurance testing in compliance with MIL-STD-883

### FUNCTIONAL DESCRIPTION

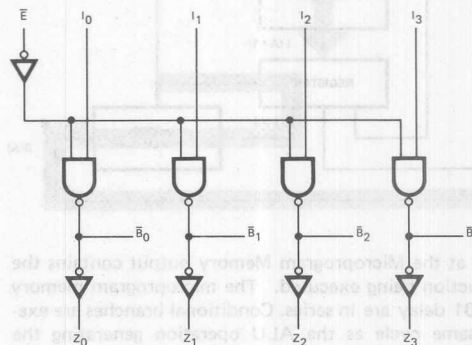
The Am2912 is a quad Bus Transceiver consisting of four high-speed bus drivers with open-collector outputs capable of sinking 100mA at 0.8 volts and four high-speed bus receivers. Each driver output is connected internally to the high-speed bus receiver in addition to being connected to the package pin. The receiver has a Schottky TTL output capable of driving 10 Schottky TTL unit loads.

An active LOW enable gate controls the four drivers so that outputs of different device drivers can be connected together for party-line operation. The enable input can be conveniently driven by active LOW decoders such as the Am25LS139.

The bus output high-drive capability in the LOW state allows party-line operation with a line impedance as low as 100Ω. The line can be terminated at both ends, and still give considerable noise margin at the receiver. The receiver typical switching point is 2.0 volts.

The Am2912 features advanced Schottky processing to minimize propagation delay. The device package also has two ground pins to improve ground current handling and allow close decoupling between  $V_{CC}$  and ground at the package. Both  $GND_1$  and  $GND_2$  should be tied to the ground bus external to the device package.

### LOGIC DIAGRAM



BLI-061

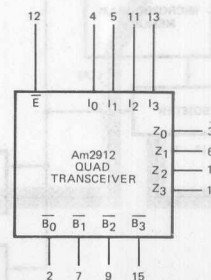
### CONNECTION DIAGRAM Top View



Note: Pin 1 is marked for orientation.

BLI-062

### LOGIC SYMBOL



$V_{CC}$  = Pin 16  
 $GND_1$  = Pin 1  
 $GND_2$  = Pin 8

BLI-063

**MAXIMUM RATINGS** (Above which the useful life may be impaired)

|   |                                |
|---|--------------------------------|
| Storage Temperature                                 | -65°C to +150°C                |
| Temperature (Ambient) Under Bias                    | -55°C to +125°C                |
| Supply Voltage to Ground Potential                  | -0.5V to +7V                   |
| DC Voltage Applied to Outputs for High Output State | -0.5V to +V <sub>CC</sub> max. |
| DC Input Voltage                                    | -0.5V to +5.5V                 |
| Output Current, Into Bus                            | 200 mA                         |
| Output Current, Into Outputs (Except Bus)           | 30 mA                          |
| DC Input Current                                    | -30 mA to +5.0 mA              |

**ELECTRICAL CHARACTERISTICS OVER OPERATING RANGE** (Unless Otherwise Noted)

|                  |                                  |                                      |              |              |
|------------------|----------------------------------|--------------------------------------|--------------|--------------|
| Am2912PC, DC, XC | T <sub>A</sub> = 0°C to +70°C    | V <sub>CC</sub> = 5.0 V ± 5% (COM'L) | MIN. = 4.75V | MAX. = 5.25V |
| Am2912DM, FM, XM | T <sub>A</sub> = -55°C to +125°C | V <sub>CC</sub> = 5.0 V ± 10% (MIL)  | MIN. = 4.5V  | MAX. = 5.5V  |

2

| Parameters       | Description                                   | Test Conditions (Note 1)   | Min.   | Typ.<br>(Note 2) | Max.  | Units |
|------------------|---|--|--------|------------------|-------|-------|
| V <sub>OH</sub>  | Output HIGH Voltage<br>(Receiver Outputs)     | V <sub>CC</sub> = MIN., I <sub>OH</sub> = -1.0mA<br>V <sub>IN</sub> = V <sub>IL</sub> or V <sub>IH</sub> | MIL    | 2.5              | 3.4   | Volts |
|                  |   |  | COM'L  | 2.7              | 3.4   |       |
| V <sub>OL</sub>  | Output LOW Voltage<br>(Receiver Outputs)      | V <sub>CC</sub> = MIN., I <sub>OL</sub> = 20mA<br>V <sub>IN</sub> = V <sub>IL</sub> or V <sub>IH</sub>   |        |                  | 0.5   | Volts |
| V <sub>IH</sub>  | Input HIGH Level<br>(Except Bus)              | Guaranteed input logical HIGH<br>for all inputs  |        | 2.0              |       | Volts |
| V <sub>IL</sub>  | Input LOW Level<br>(Except Bus)               | Guaranteed input logical LOW<br>for all inputs   |        |                  | 0.8   | Volts |
| V <sub>I</sub>   | Input Clamp Voltage<br>(Except Bus)           | V <sub>CC</sub> = MIN., I <sub>IN</sub> = -18mA  |        |                  | -1.2  | Volts |
| I <sub>IL</sub>  | Input LOW Current<br>(Except Bus)             | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 0.4V   | Enable |                  | -0.36 | mA    |
|                  |   |  | Data   |                  | -0.54 |       |
| I <sub>IH</sub>  | Input HIGH Current<br>(Except Bus)            | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 2.7V   | Enable |                  | 20    | μA    |
|                  |   |  | Data   |                  | 30    |       |
| I <sub>I</sub>   | Input HIGH Current<br>(Except Bus)            | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 5.5V   |        |                  | 100   | μA    |
| I <sub>SC</sub>  | Output Short Circuit Current<br>(Except Bus)  | V <sub>CC</sub> = MAX. (Note 3)  | MIL    | -20              | -55   | mA    |
|                  |   |  | COM'L  | -18              | -60   |       |
| I <sub>CCL</sub> | Power Supply Current<br>(All Bus Outputs LOW) | V <sub>CC</sub> = MAX.<br>Enable = GND   |        | 45               | 70    | mA    |

**Bus Input/Output Characteristics**

| Parameters       | Description                     | Test Conditions (Note 1)                   | Min.  | Typ.<br>(Note 2)        | Max. | Units |
|------------------|---------------------------------|--|-------|-------------------------|------|-------|
| V <sub>OL</sub>  | Output LOW Voltage              | V <sub>CC</sub> = MIN.                     | MIL   | I <sub>OL</sub> = 40mA  | 0.33 | Volts |
|                  |                                 |  |       | I <sub>OL</sub> = 70mA  | 0.42 |       |
|                  |                                 |  |       | I <sub>OL</sub> = 100mA | 0.51 |       |
|                  |                                 | V <sub>CC</sub> = MAX.                     | COM'L | I <sub>OL</sub> = 40mA  | 0.33 |       |
|                  |                                 |  |       | I <sub>OL</sub> = 70mA  | 0.42 |       |
|                  |                                 |  |       | I <sub>OL</sub> = 100mA | 0.51 |       |
| I <sub>O</sub>   | Bus Leakage Current             | V <sub>CC</sub> = MAX.                     | MIL   | V <sub>O</sub> = 0.8V   |      | μA    |
|                  |                                 |  |       | V <sub>O</sub> = 4.5V   | 200  |       |
|                  |                                 |  |       | V <sub>O</sub> = 4.5V   | 100  |       |
| I <sub>OFF</sub> | Bus Leakage Current (Power Off) | V <sub>O</sub> = 4.5V                      |       |                         | 100  | μA    |
| V <sub>TH</sub>  | Receiver Input HIGH Threshold   | Bus Enable = 2.4V<br>V <sub>CC</sub> = MAX | MIL   | 2.4                     | 2.0  | Volts |
|                  |                                 |  | COM'L | 2.25                    | 2.0  |       |
| V <sub>TL</sub>  | Receiver Input LOW Threshold    | Bus Enable = 2.4V<br>V <sub>CC</sub> = MIN | MIL   |                         | 2.0  | Volts |
|                  |                                 |  | COM'L |                         | 1.75 |       |

- Notes: 1. For conditions shown as MIN. or MAX., use the appropriate value specified under Electrical Characteristics for the applicable device type.  
2. Typical limits are at V<sub>CC</sub> = 5.0 V, 25°C ambient and maximum loading.  
3. Not more than one output should be shorted at a time. Duration of the short circuit test should not exceed one second.

SWITCHING CHARACTERISTICS ( $T_A = 25^\circ\text{C}$ ,  $V_{CC} = 5.0\text{V}$ )

| Parameters | Description         | Test Conditions   | Min | Typ | Max | Units |
|------------|---------------------|---|-----|-----|-----|-------|
| $t_{PLH}$  | Data Input to Bus   | $R_B = 50\Omega$<br>$C_B = 50\text{pF}$ (Note 1)  |     | 10  | 15  | ns    |
| $t_{PHL}$  |                     |   |     | 10  | 15  | ns    |
| $t_{PLH}$  | Enable Input to Bus | $R_B = 50\Omega$ , $R_L = 280\Omega$<br>$C_B = 50\text{pF}$ (Note 1), $C_L = 15\text{pF}$ |     | 14  | 18  | ns    |
| $t_{PHL}$  |                     |   |     | 13  | 18  | ns    |
| $t_{PLH}$  | Bus to Receiver Out | $R_B = 50\Omega$ , $R_L = 280\Omega$<br>$C_B = 50\text{pF}$ (Note 1), $C_L = 15\text{pF}$ |     | 10  | 15  | ns    |
| $t_{PHL}$  |                     |   |     | 10  | 15  | ns    |
| $t_r$      | Bus                 | $R_B = 50\Omega$  | 4.0 | 10  |     | ns    |
| $t_f$      | Bus                 | $C_B = 50\text{pF}$ (Note 1)  | 2.0 | 4.0 |     | ns    |

Note 1. Includes probe and jig capacitance.

## TRUTH TABLE

| Inputs    |   | Outputs   |           |
|-----------|---|-----------|-----------|
| $\bar{E}$ | I | $\bar{B}$ | Z         |
| L         | L | H         | L         |
| L         | H | L         | H         |
| H         | X | Y         | $\bar{Y}$ |

H = HIGH Voltage Level

L = LOW Voltage Level

X = Don't Care

Y = Voltage Level of Bus (Assumes Control by Another Bus Transceiver)

## ORDERING INFORMATION

Order the part number according to the table below to obtain the desired package, temperature range and screening level.

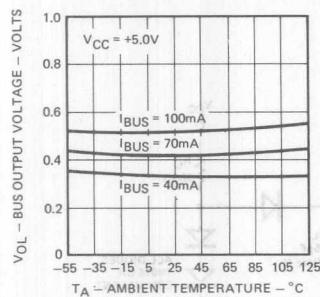
| Order Number | Package Type (Note 1) | Operating Range (Note 2) | Screening Level (Note 3)                             |
|--------------|-----------------------|--------------------------|--|
| AM2912PC     | P-16-1                | C                        | C-1  |
| AM2912DC     | D-16-1                | C                        | C-1  |
| AM2912DC-B   | D-16-1                | C                        | B-1  |
| AM2912DM     | D-16-1                | M                        | C-3  |
| AM2912DM-B   | D-16-1                | M                        | B-3  |
| AM2912FM     | F-16-1                | M                        | C-3  |
| AM2912FM-B   | F-16-1                | M                        | B-3  |
| AM2912XC     | Dice                  | C                        | Visual inspection<br>to MIL-STD-883<br>Method 2010B. |
| AM2912XM     | Dice                  | M                        |  |

## Notes:

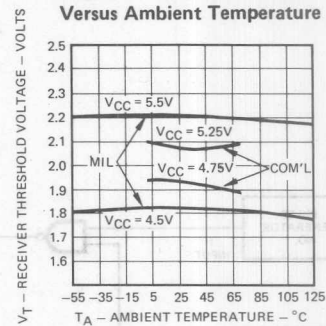
1. P = Molded DIP, D = Hermetic DIP, F = Flat Pak. Number following letter is number of leads. See Appendix B for detailed outline. Where Appendix B contains several dash numbers, any of the variations of the package may be used unless otherwise specified.
2. C = 0 to  $70^\circ\text{C}$ ,  $V_{CC} = 4.75\text{V}$  to  $5.25\text{V}$ , M =  $-55$  to  $+125^\circ\text{C}$ ,  $V_{CC} = 4.50\text{V}$  to  $5.50\text{V}$ .
3. See Appendix A for details of screening. Levels C-1 and C-3 conform to MIL-STD-883, Class C, Level B-3 conforms to MIL-STD-883, Class B.



## TYPICAL PERFORMANCE CURVES

Typical Bus Output Low Voltage  
Versus Ambient Temperature

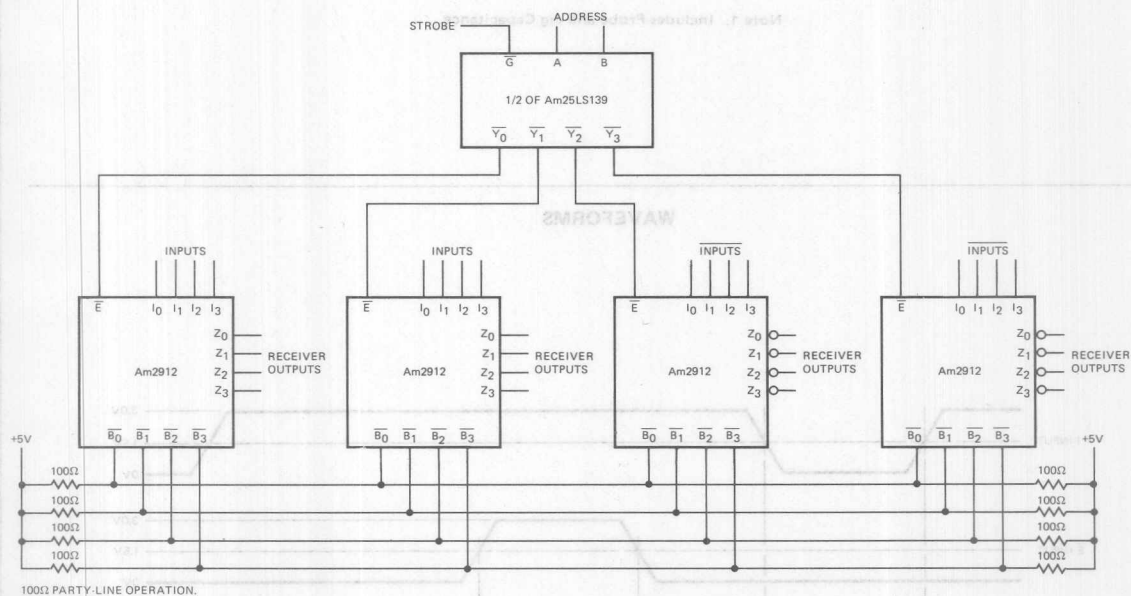
BLI-064

Receiver Threshold Variation  
Versus Ambient Temperature

BLI-065

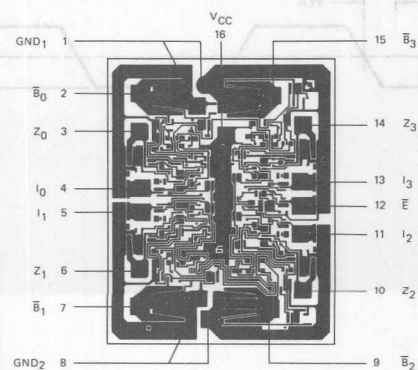
2

## TYPICAL APPLICATION



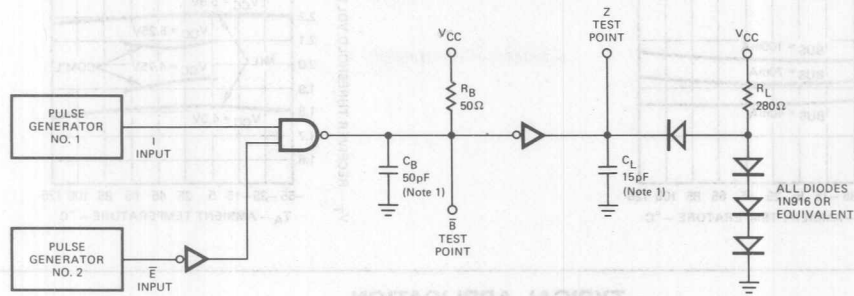
BLI-066

## Metallization and Pad Layout



DIE SIZE 0.059" X 0.075"

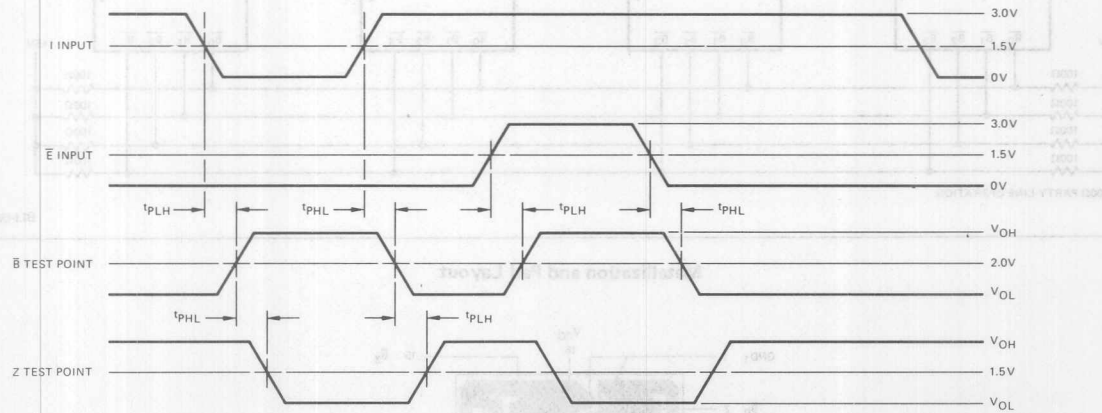
# TEST CIRCUIT



BLI-067

Note 1. Includes Probe and Jig Capacitance.

# WAVEFORMS



BLI-068

## Distinctive Characteristics

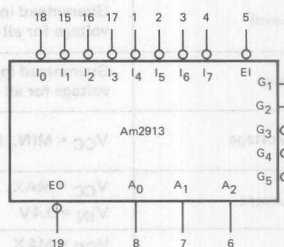
- Encodes eight lines to three-line binary
- Expands use of Am2914
- Cascadable
- Similar in function to Am54LS/74LS/25LS148/2513
- Gated three-state output
- Advanced Low-Power Schottky processing
- 100% reliability assurance testing in compliance with MIL-STD-883

## FUNCTIONAL DESCRIPTION

The Low-Power Schottky Priority Interrupt Expander is an extension of the Am2900 series of Bipolar Processor family and is used to expand and prioritize the output of the Am2914 Priority Interrupt circuit. Affording an increase of vectored priority interrupt in groups of eight, this unit accepts active LOW inputs and produces a three-state active HIGH output prioritized from active  $\bar{I}_7$  to  $\bar{I}_0$ . The output is gated by five control signals, three active LOW and two active HIGH. Also provided is a cascade input ( $\bar{E}I$ ) and Enable Output ( $\bar{E}O$ ).

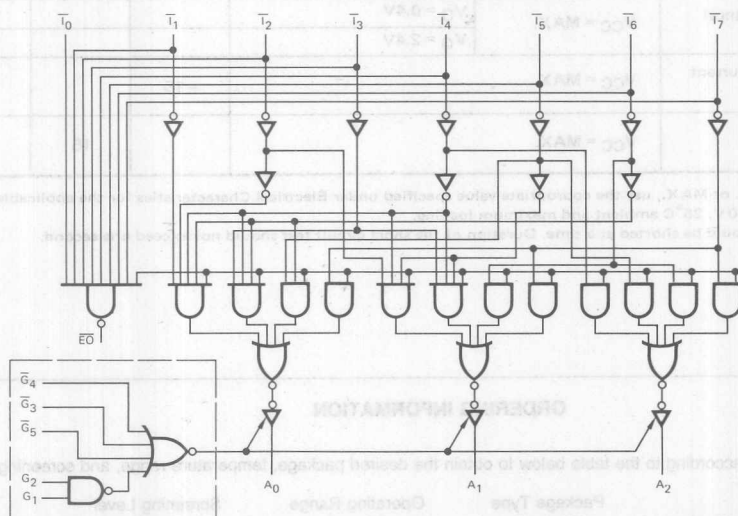
One Am2913 will accept and encode group signal lines from up to 8 Am2914's (64 levels of interrupt). Additional Am2913's may be used to encode more interrupt levels.

## LOGIC SYMBOL



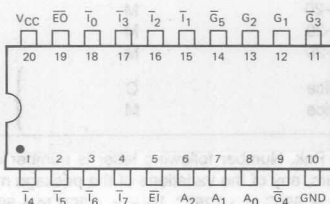
MPR-118

## LOGIC DIAGRAM



MPR-119

## CONNECTION DIAGRAM Top View



Note: Pin 1 is marked for orientation.

MPR-120

## Am2913

## ELECTRICAL CHARACTERISTICS

The Following Conditions Apply Unless Otherwise Specified:

COM'L  $T_A = 0^\circ\text{C to } +70^\circ\text{C}$   $V_{CC} = 5.0\text{V} \pm 5\%$  MIN. = 4.75V MAX. = 5.25V  
 MIL  $T_A = -55^\circ\text{C to } +125^\circ\text{C}$   $V_{CC} = 5.0\text{V} \pm 10\%$  MIN. = 4.50V MAX. = 5.50V

## DC CHARACTERISTICS OVER OPERATING RANGE

| Parameters | Description                               | Test Conditions (Note 1)                                       | Min.  | Typ.<br>(Note 2) | Max. | Units         |
|------------|---|--|---|------------------|------|---------------|
| $V_{OH}$   | Output HIGH Voltage                       | $V_{CC} = \text{MIN.}$<br>$V_{IN} = V_{IH} \text{ or } V_{IL}$ | MIL, $I_{OH} = -1.0\text{mA}$   | 2.4              | 3.4  | Volts         |
|            |   |  | COM'L, $I_{OH} = -2.6\text{mA}$   | 2.4              | 3.2  |               |
|            |   | $\overline{EO}$ , $I_{OH} = -440\mu\text{A}$                   | MIL   | 2.5              | 3.4  |               |
|            |   |  | COM'L   | 2.7              | 3.4  |               |
| $V_{OL}$   | Output LOW Voltage                        | $V_{CC} = \text{MIN.}$<br>$V_{IN} = V_{IH} \text{ or } V_{IL}$ | $I_{OL} = 4.0\text{mA}$   |                  | 0.4  | Volts         |
|            |   |  | $I_{OL} = 8.0\text{mA}$   |                  | 0.45 |               |
|            |   |  | $I_{OL} = 12\text{mA}(A_n \text{ Outputs})$   |                  | 0.5  |               |
| $V_{IH}$   | Input HIGH Level                          | Guaranteed input logical HIGH voltage for all inputs           | 2.0   |                  |      | Volts         |
| $V_{IL}$   | Input LOW Level                           | Guaranteed input logical LOW voltage for all inputs            | MIL   |                  | 0.7  | Volts         |
|            |   |  | COM'L   |                  | 0.8  |               |
| $V_I$      | Input Clamp Voltage                       | $V_{CC} = \text{MIN.}$ , $I_{IN} = -18\text{mA}$               |   |                  | -1.5 | Volts         |
| $I_{IL}$   | Input LOW Current                         | $V_{CC} = \text{MAX.}$<br>$V_{IN} = 0.4\text{V}$               | $\overline{EI}, G_1, G_2, \overline{G_3}, \overline{G_4}, \overline{G_5}, \overline{I_0}$ |                  | 0.4  | mA            |
|            |   |  | All others  |                  | 0.8  |               |
| $I_{IH}$   | Input HIGH Current                        | $V_{CC} = \text{MAX.}$<br>$V_{IN} = 2.7\text{V}$               | $\overline{EI}, G_1, G_2, \overline{G_3}, \overline{G_4}, \overline{G_5}, \overline{I_0}$ |                  | 20   | $\mu\text{A}$ |
|            |   |  | All others  |                  | 40   |               |
| $I_I$      | Input HIGH Current                        | $V_{CC} = \text{MAX.}$<br>$V_{IN} = 7.0\text{V}$               | $\overline{EI}, G_1, G_2, \overline{G_3}, \overline{G_4}, \overline{G_5}, \overline{I_0}$ |                  | 0.1  | mA            |
|            |   |  | All others  |                  | 0.2  |               |
| $I_O$      | Off-State (High-Impedance) Output Current | $V_{CC} = \text{MAX.}$   | $V_O = 0.4\text{V}$   |                  | -20  | $\mu\text{A}$ |
|            |   |  | $V_O = 2.4\text{V}$   |                  | 20   |               |
| $I_{SC}$   | Output Short Circuit Current (Note 3)     | $V_{CC} = \text{MAX.}$   | -15   |                  | -85  | mA            |
| $I_{CC}$   | Power Supply Current (Note 4)             | $V_{CC} = \text{MAX.}$   |   | 15               | 24   | mA            |

- Notes: 1. For conditions shown as MIN. or MAX., use the appropriate value specified under Electrical Characteristics for the applicable device type.  
 2. Typical limits are at  $V_{CC} = 5.0\text{V}$ ,  $25^\circ\text{C}$  ambient and maximum loading.  
 3. Not more than one output should be shorted at a time. Duration of the short circuit test should not exceed one second.  
 4. All inputs and outputs open.

## ORDERING INFORMATION

Order the part number according to the table below to obtain the desired package, temperature range, and screening level.

| Order Number | Package Type<br>(Note 1) | Operating Range<br>(Note 2) | Screening Level<br>(Note 3)                          |
|--------------|--------------------------|-----------------------------|--|
| AM2913PC     | P-20                     | C                           | C-1  |
| AM2913DC     | D-20                     | C                           | C-1  |
| AM2913DC-B   | D-20                     | C                           | B-1  |
| AM2913DM     | D-20                     | M                           | C-3  |
| AM2913DM-B   | D-20                     | M                           | B-3  |
| AM2913FM     | F-20                     | M                           | C-3  |
| AM2913FM-B   | F-20                     | M                           | B-3  |
| AM2913XC     | Dice                     | C                           | Visual inspection<br>to MIL-STD-883<br>Method 2010B. |
| AM2913XM     | Dice                     | M                           |  |

- Notes: 1. P = Molded DIP, D = Hermetic DIP, F = Flat Pak. Number following letter is number of leads. See Appendix B for detailed outline. Where Appendix B contains several dash numbers, any of the variations of the package may be used unless otherwise specified.  
 2. C =  $0^\circ\text{C to } +70^\circ\text{C}$ ,  $V_{CC} = 4.75\text{V to } 5.25\text{V}$ , M =  $-55^\circ\text{C to } +125^\circ\text{C}$ ,  $V_{CC} = 4.50\text{V to } 5.50\text{V}$ .  
 3. See Appendix A for details of screening. Levels C-1 and C-3 conform to MIL-STD-883, Class C. Level B-3 conforms to MIL-STD-883, Class B.



**MAXIMUM RATINGS** (Above which the useful life may be impaired)

|   |                                |
|---|--------------------------------|
| Storage Temperature                                 | -65°C to +150°C                |
| Temperature (Ambient) Under Bias                    | -55°C to +125°C                |
| Supply Voltage to Ground Potential Continuous       | -0.5V to +7.0V                 |
| DC Voltage Applied to Outputs for High Output State | -0.5V to +V <sub>CC</sub> max. |
| DC Input Voltage                                    | -0.5V to +7.0V                 |
| DC Output Current, Into Outputs                     | 30mA                           |
| DC Input Current                                    | -30mA to +5.0mA                |

**SWITCHING CHARACTERISTICS**(T<sub>A</sub> = +25°C, V<sub>CC</sub> = 5.0V)

| Parameters       | Description  | Min. | Typ. | Max. | Units | Test Conditions                                  |
|------------------|--|------|------|------|-------|--|
| t <sub>PLH</sub> | $\overline{I}_i$ to A <sub>N</sub> (In-phase)                      |      | 17   | 25   | ns    | C <sub>L</sub> = 15pF<br>R <sub>L</sub> = 2.0kΩ  |
| t <sub>PHL</sub> |  |      | 17   | 25   |       |  |
| t <sub>PLH</sub> | $\overline{I}_i$ to A <sub>N</sub> (Out-phase)                     |      | 11   | 17   | ns    |  |
| t <sub>PHL</sub> |  |      | 12   | 18   |       |  |
| t <sub>PLH</sub> | $\overline{I}_i$ to $\overline{EO}$                                |      | 7.0  | 11   | ns    |  |
| t <sub>PHL</sub> |  |      | 24   | 36   |       |  |
| t <sub>PLH</sub> | $\overline{EI}$ to $\overline{EO}$                                 |      | 11   | 17   | ns    |  |
| t <sub>PHL</sub> |  |      | 23   | 34   |       |  |
| t <sub>PLH</sub> | $\overline{EI}$ to A <sub>N</sub>                                  |      | 12   | 18   | ns    |  |
| t <sub>PHL</sub> |  |      | 14   | 21   |       |  |
| t <sub>ZH</sub>  | G <sub>1</sub> or G <sub>2</sub> to A <sub>N</sub>                 |      | 23   | 40   | ns    | C <sub>L</sub> = 5.0pF<br>R <sub>L</sub> = 2.0kΩ |
| t <sub>ZL</sub>  |  |      | 20   | 37   |       |  |
| t <sub>ZH</sub>  | $\overline{G}_3, \overline{G}_4, \overline{G}_5$ to A <sub>N</sub> |      | 20   | 30   | ns    |  |
| t <sub>ZL</sub>  |  |      | 18   | 27   |       |  |
| t <sub>HZ</sub>  | G <sub>1</sub> or G <sub>2</sub> to A <sub>N</sub>                 |      | 17   | 27   | ns    |  |
| t <sub>LZ</sub>  |  |      | 19   | 28   |       |  |
| t <sub>HZ</sub>  | $\overline{G}_3, \overline{G}_4, \overline{G}_5$ to A <sub>N</sub> |      | 16   | 24   | ns    |  |
| t <sub>LZ</sub>  |  |      | 18   | 27   |       |  |

**SWITCHING CHARACTERISTICS  
OVER OPERATING RANGE\***

| Switching Characteristics<br>Over Operating Range* |  | Am2913 COM'L  |      | Am2913 MIL  |      | Units                      Test Conditions |  |
|--|--|---|------|---|------|--|--|
|  |  | T <sub>A</sub> = 0°C to +70°C<br>V <sub>CC</sub> = 5.0V ±5% |      | T <sub>A</sub> = -55°C to +125°C<br>V <sub>CC</sub> = 5.0V ±10% |      |  |  |
|  |  | Min.  | Max. | Min.  | Max. |  |  |
| Parameters   | Description  |   |      |   |      |  |  |
| t <sub>PLH</sub>                                   | $\overline{I}_i$ to A <sub>n</sub> (In-phase)                      |   | 31   |   | 37   | ns   | C <sub>L</sub> = 50pF<br>R <sub>L</sub> = 2.0kΩ  |
| t <sub>PHL</sub>                                   |  |   | 30   |   | 34   |  |  |
| t <sub>PLH</sub>                                   | $\overline{I}_i$ to A <sub>n</sub> (Out-phase)                     |   | 22   |   | 27   | ns   |  |
| t <sub>PHL</sub>                                   |  |   | 22   |   | 25   |  |  |
| t <sub>PLH</sub>                                   | $\overline{I}_i$ to $\overline{EO}$                                |   | 15   |   | 18   | ns   |  |
| t <sub>PHL</sub>                                   |  |   | 48   |   | 60   |  |  |
| t <sub>PLH</sub>                                   | $\overline{EI}$ to $\overline{EO}$                                 |   | 19   |   | 21   | ns   |  |
| t <sub>PHL</sub>                                   |  |   | 46   |   | 57   |  |  |
| t <sub>PLH</sub>                                   | $\overline{EI}$ to A <sub>n</sub>                                  |   | 22   |   | 25   | ns   |  |
| t <sub>PHL</sub>                                   |  |   | 27   |   | 32   |  |  |
| t <sub>ZH</sub>                                    | G <sub>1</sub> or G <sub>2</sub> to A <sub>n</sub>                 |   | 42   |   | 49   | ns   | C <sub>L</sub> = 5.0pF<br>R <sub>L</sub> = 2.0kΩ |
| t <sub>ZL</sub>                                    |  |   | 43   |   | 49   |  |  |
| t <sub>ZH</sub>                                    | $\overline{G}_3, \overline{G}_4, \overline{G}_5$ to A <sub>n</sub> |   | 36   |   | 43   | ns   |  |
| t <sub>ZL</sub>                                    |  |   | 35   |   | 43   |  |  |
| t <sub>HZ</sub>                                    | G <sub>1</sub> or G <sub>2</sub> to A <sub>n</sub>                 |   | 34   |   | 40   | ns   |  |
| t <sub>LZ</sub>                                    |  |   | 34   |   | 40   |  |  |
| t <sub>HZ</sub>                                    | $\overline{G}_3, \overline{G}_4, \overline{G}_5$ to A <sub>n</sub> |   | 30   |   | 35   | ns   |  |
| t <sub>LZ</sub>                                    |  |   | 31   |   | 35   |  |  |

\*AC performance over the operating temperature range is guaranteed by testing defined in Group A, Subgroup 9.

Note: i = 0 to 7  
n = 0 to 2

**EI**

Enable input provided to allow cascaded operation

**E0**

Enable output provided to enable the next lower order priority chip

**G1, G2**

Active high three-state output controls

**G3, G4, G5**

Active low three-state output controls

**T0-7**

Active low encoder inputs

### TRUTH TABLE

| Inputs |    |    |    |    |    |    |    |    |  | Outputs |    |    |    |
|--------|----|----|----|----|----|----|----|----|--|---------|----|----|----|
| EI     | T0 | T1 | T2 | T3 | T4 | T5 | T6 | T7 |  | A0      | A1 | A2 | E0 |
| H      | X  | X  | X  | X  | X  | X  | X  | X  |  | L       | L  | L  | H  |
| L      | H  | H  | H  | H  | H  | H  | H  | H  |  | L       | L  | L  | L  |
| L      | X  | X  | X  | X  | X  | X  | X  | L  |  | H       | H  | H  | H  |
| L      | X  | X  | X  | X  | X  | X  | L  | H  |  | L       | H  | H  | H  |
| L      | X  | X  | X  | X  | X  | L  | H  | H  |  | H       | L  | H  | H  |
| L      | X  | X  | X  | X  | L  | H  | H  | H  |  | L       | L  | H  | H  |
| L      | X  | X  | X  | L  | H  | H  | H  | H  |  | H       | H  | L  | H  |
| L      | X  | X  | L  | H  | H  | H  | H  | H  |  | L       | H  | L  | H  |
| L      | X  | L  | H  | H  | H  | H  | H  | H  |  | H       | L  | L  | H  |
| L      | L  | H  | H  | H  | H  | H  | H  | H  |  | L       | L  | L  | H  |

H = HIGH Voltage Level

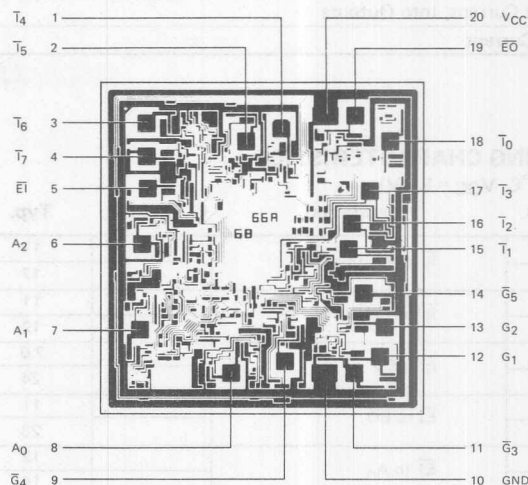
L = LOW Voltage Level

X = Don't Care

For G1 = H, G2 = H, G3 = L, G4 = L, G5 = L

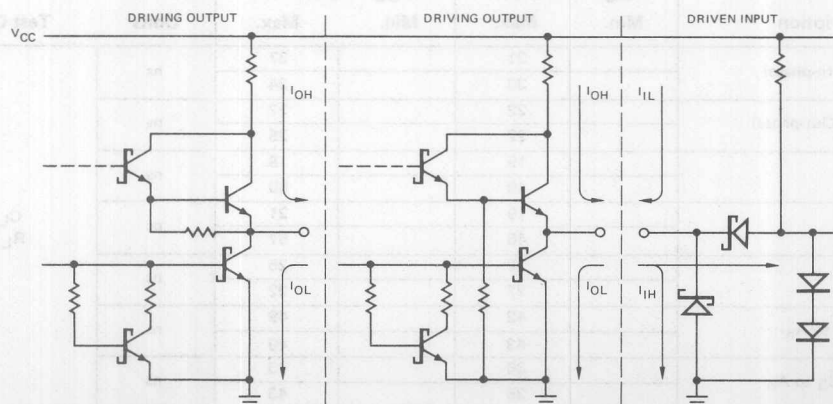
| G1 | G2 | G3 | G4 | G5 | A0      | A1 | A2 |
|----|----|----|----|----|---------|----|----|
| H  | H  | L  | L  | L  | Enabled |    |    |
| L  | X  | X  | X  | X  | Z       | Z  | Z  |
| X  | L  | X  | X  | X  | Z       | Z  | Z  |
| X  | X  | H  | X  | X  | Z       | Z  | Z  |
| X  | X  | X  | H  | X  | Z       | Z  | Z  |
| X  | X  | X  | X  | H  | Z       | Z  | Z  |

Z = HIGH Impedance



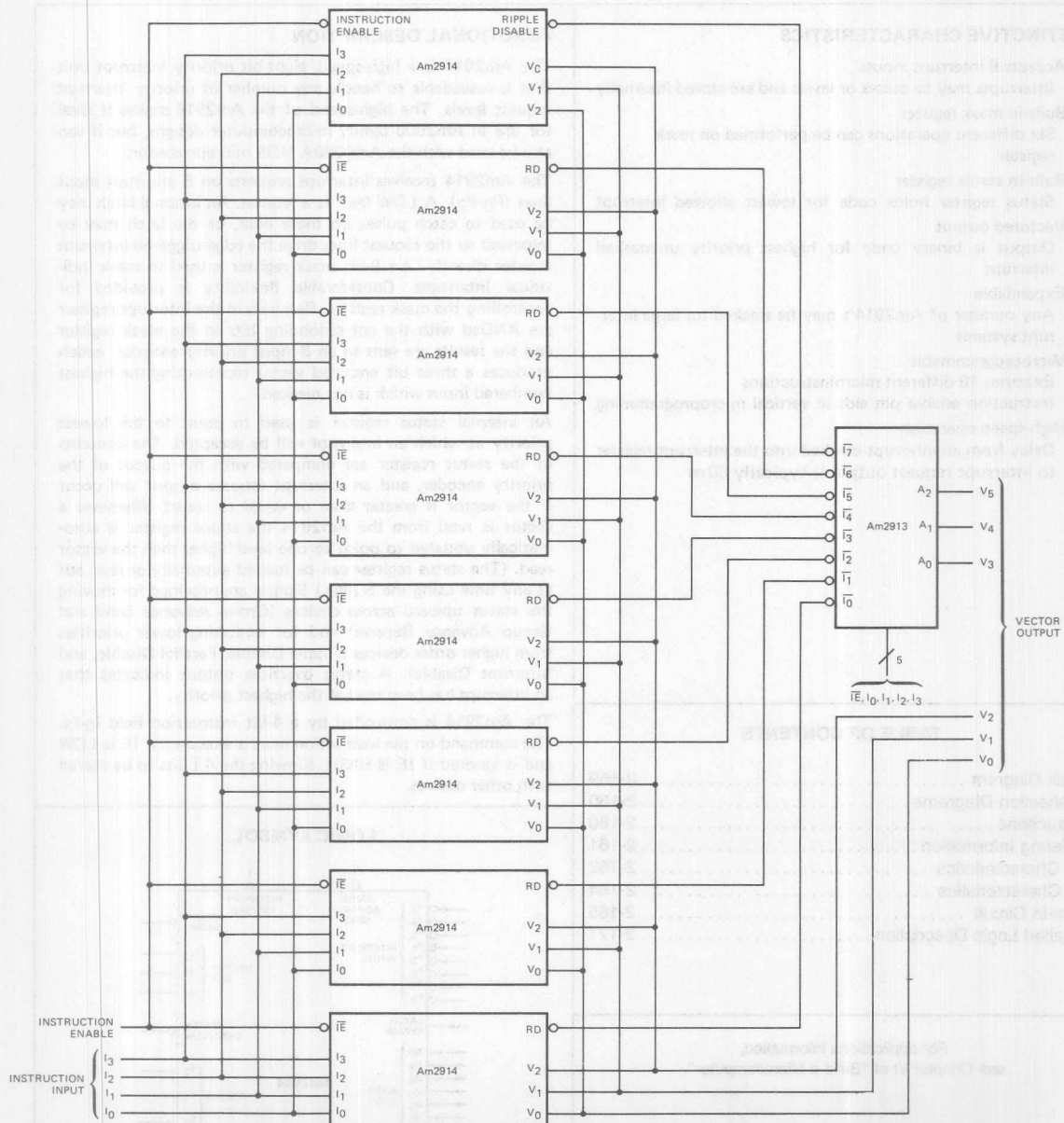
DIE SIZE 0.082" X 0.085"

### LOW-POWER SCHOTTKY INPUT/OUTPUT CURRENT INTERFACE CONDITIONS



Note: Actual current flow direction shown.

MPR-121



Shown above is the connection of the instruction lines and vector output lines in a 64-input priority interrupt system. The Am2913 is used to encode the most significant bits associated with the vector output.

# Am2914

## Vectored Priority Interrupt Controller

### DISTINCTIVE CHARACTERISTICS

- Accepts 8 interrupt inputs  
Interrupts may be pulses or levels and are stored internally
- Built-in mask register  
Six different operations can be performed on mask register
- Built-in status register  
Status register holds code for lowest allowed interrupt
- Vectored output  
Output is binary code for highest priority un-masked interrupt
- Expandable  
Any number of Am2914's may be stacked for large interrupt systems
- Microprogrammable  
Executes 16 different microinstructions  
Instruction enable pin aids in vertical microprogramming
- High-speed operation  
Delay from an interrupt clocked into the interrupt register to interrupt request output is typically 60 ns

### FUNCTIONAL DESCRIPTION

The Am2914 is a high-speed, eight-bit priority interrupt unit that is cascadable to handle any number of priority interrupt request levels. The high-speed of the Am2914 makes it ideal for use in Am2900 family microcomputer designs, but it can also be used with the Am9080A MOS microprocessor.

The Am2914 receives interrupt requests on 8 interrupt input lines (P<sub>0</sub>-P<sub>7</sub>). A LOW level is a request. An internal latch may be used to catch pulses on these lines, or the latch may be bypassed so the request lines drive the edge-triggered interrupt register directly. An 8-bit mask register is used to mask individual interrupts. Considerable flexibility is provided for controlling the mask register. Requests in the interrupt register are ANDed with the corresponding bits in the mask register and the results are sent to an 8-input priority encoder, which produces a three bit encoded vector representing the highest numbered input which is not masked.

An internal status register is used to point to the lowest priority at which an interrupt will be accepted. The contents of the status register are compared with the output of the priority encoder, and an interrupt request output will occur if the vector is greater than or equal to status. Whenever a vector is read from the Am2914 the status register is automatically updated to point to one level higher than the vector read. (The status register can be loaded externally or read out at any time using the S pins.) Signals are provided for moving the status upward across devices (Group Advance Send and Group Advance Receive) and for inhibiting lower priorities from higher order devices (Ripple Disable, Parallel Disable, and Interrupt Disable). A status overflow output indicates that an interrupt has been read at the highest priority.

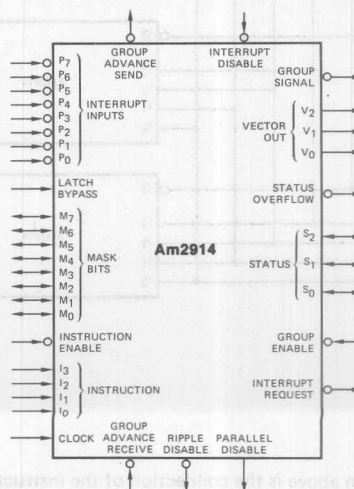
The Am2914 is controlled by a 4-bit instruction field I<sub>0</sub>-I<sub>3</sub>. The command on the instruction lines is executed if IE is LOW and is ignored if IE is HIGH, allowing the 4 I bits to be shared with other devices.

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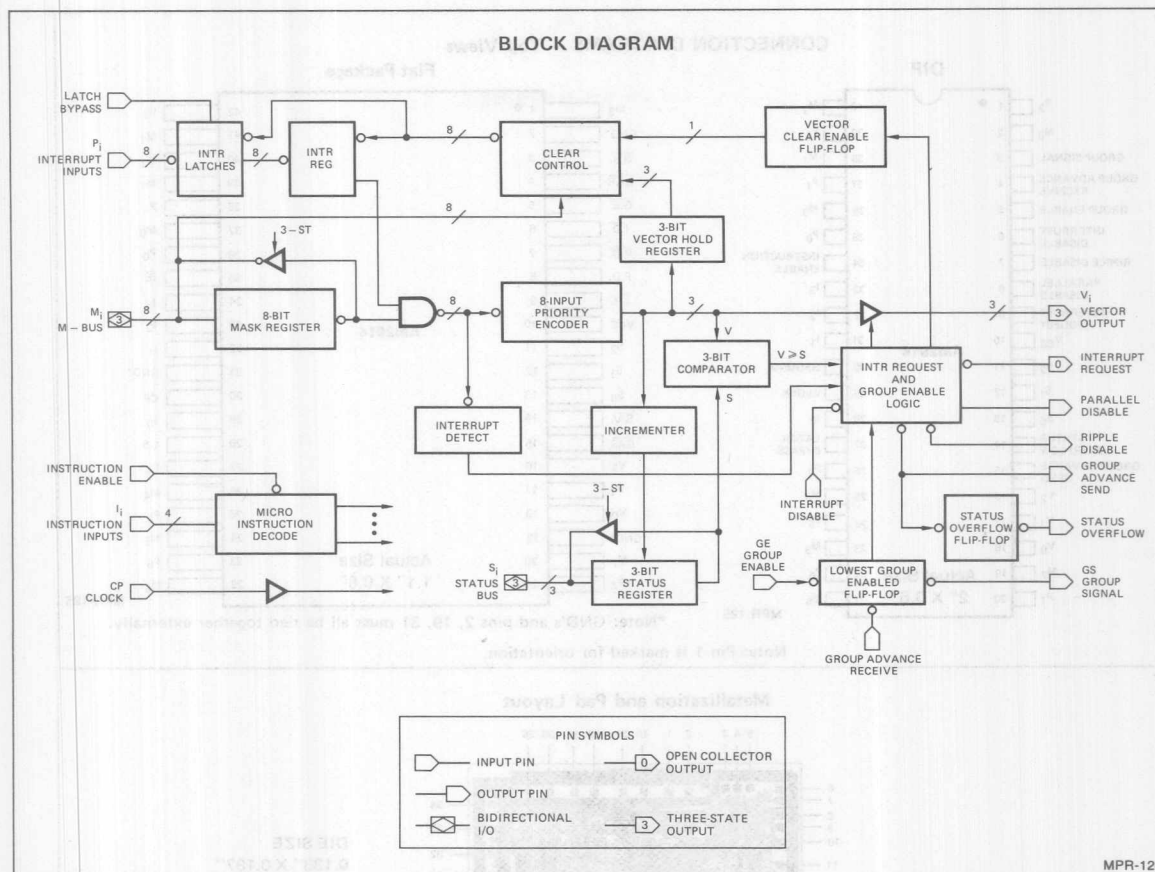
|                                  |       |
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For applications information,  
see Chapter VI of "Build a Microcomputer".

### LOGIC SYMBOL







### BLOCK DIAGRAM DESCRIPTION

The Microinstruction Decode circuitry decodes the Interrupt Microinstructions and generates required control signals for the chip.

The Interrupt Register holds the Interrupt Inputs and is an eight-bit, edge-triggered register which is set on the rising edge of the CP Clock signal.

The Interrupt latches are set/reset-type latches. When the Latch Bypass signal is LOW, the latches are enabled and act as negative pulse catchers on the inputs to the Interrupt Register. When the Latch Bypass signal is HIGH, the Interrupt latches are transparent.

The Mask Register holds the eight mask bits associated with the eight interrupt levels. The register may be loaded from or read to the M Bus. Also, the entire register or individual mask bits may be set or cleared.

The Interrupt Detect circuitry detects the presence of any unmasked Interrupt Input. The eight-input Priority Encoder determines the highest priority, non-masked Interrupt Input and forms a binary coded interrupt vector. Following a Vector Read, the three-bit Vector Hold Register holds the binary coded interrupt vector. This stored vector is used for clearing interrupts.

The three-bit Status Register holds the status bits and may be loaded from or read to the S Bus. During a Vector Read, the Incrementer increments the interrupt vector by one, and the result is clocked into the Status Register. Thus the Status

Register always points to the lowest level at which an interrupt will be accepted.

The three-bit Comparator compares the Interrupt Vector with the contents of the Status Register and indicates if the Interrupt Vector is greater than or equal to the contents of the Status Register.

The Lowest Group Enabled Flip-Flop is used when a number of 2914's are cascaded. In a cascaded system, only one Lowest Group Enabled Flip-Flop is LOW at a time. It indicates the eight interrupt group, which contains the lowest priority interrupt level which will be accepted and is used to form the higher order status bits.

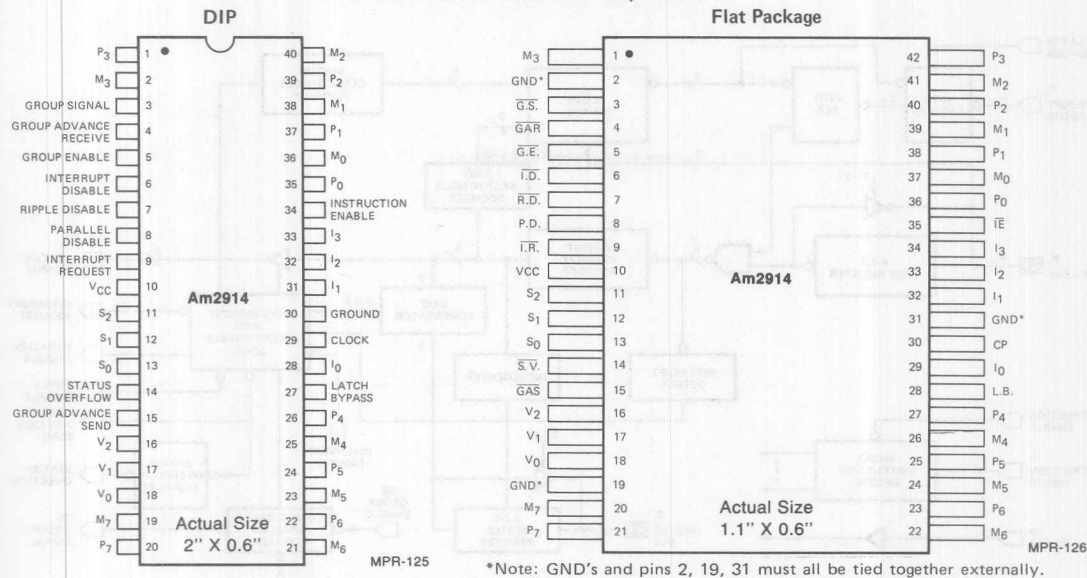
The Interrupt Request and Group Enable logic contain various gating to generate the Interrupt Request, Parallel Disable, Ripple Disable, and Group Advance Send signals.

The Status Overflow signal is used to disable all interrupts. It indicates the highest priority interrupt vector has been read and the Status Register has overflowed.

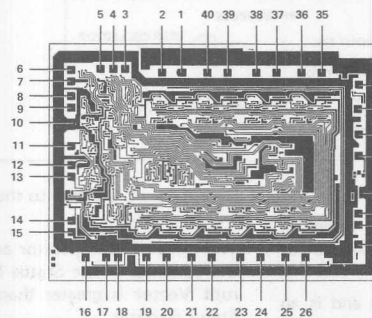
The Clear Control logic generates the eight individual clear signals for the bits in the Interrupt Latches and Register. The Vector Clear Enable Flip-Flop indicates if the last vector read was from this group. When it is set, it enables the Clear Control Logic.

The CP clock signal is used to clock the Interrupt Register, Mask Register, Status Register, Vector Hold Register, and the Lowest Group Enabled, Vector Clear Enable and Status Overflow Flip-Flops, all on the clock LOW-to-HIGH transition.

# CONNECTION DIAGRAMS — Top Views



## Metallization and Pad Layout



DIE SIZE  
0.133" X 0.187"  
Numbers correspond  
to DIP pin-out.

**TABLE I**  
**MICROINSTRUCTION SET FOR Am2914 PRIORITY INTERRUPT CIRCUIT**

| Decimal<br>$I_3 I_2 I_1 I_0$ | Mnemonic | Instruction   | Decimal<br>$I_3 I_2 I_1 I_0$ | Mnemonic | Instruction   |
|------------------------------|----------|---|------------------------------|----------|---|
| 14                           | LDM      | Load mask register from M bus                                   | 5                            | RDVC     | Read vector output to V outputs, load V+1 into status register, load V into vector hold register and set vector clear enable flip-flop. |
| 7                            | RDM      | Read mask register to M bus                                     |                              |          |   |
| 12                           | CLRM     | Clear mask register (enables all priorities)                    |                              |          |   |
| 8                            | SETM     | Set mask register (inhibits all interrupts)                     |                              |          |   |
| 10                           | BCLRM    | Bit clear mask register from M bus                              | 1                            | CLRIN    | Clear all interrupts  |
| 11                           | BSETM    | Bit set mask register from M bus                                | 3                            | CLRMR    | Clear interrupts from mask register data (uses the M bus)   |
|                              |          |   | 2                            | CLRMB    | Clear interrupts from M bus data  |
| 9                            | LDSTA    | Load status register from S bus and LGE flip-flop from GE input | 4                            | CLRVC    | Clear the individual interrupt associated with the last vector read   |
| 6                            | RDSTA    | Read status register to S bus                                   |                              |          |   |
|                              |          |   |                              |          |   |
| 15                           | ENIN     | Interrupt Request Control Enable interrupt request              | 0                            | MCLR     | Master Clear Clear all interrupts, clear mask register, clear status register, clear LGE flip-flop, enable interrupt request.           |
| 13                           | DISIN    | Disable interrupt request                                       |                              |          |   |

## STANDARD SCREENING

(Conforms to MIL-STD-883 for Class C Parts)

| Step   | MIL-STD-883 Method | Conditions                                | Level        |              |
|--|--------------------|---|--------------|--------------|
|  |                    |   | Am2914PC, DC | Am2914DM, FM |
| Pre-Seal Visual Inspection                         | 2010               | B   | 100%         | 100%         |
| Stabilization Bake                                 | 1008               | C 24-hour<br>150°C                        | 100%         | 100%         |
| Temperature Cycle                                  | 1010               | C -65°C to +150°C<br>10 cycles            | 100%         | 100%         |
| Centrifuge   | 2001               | B 10,000 G                                | 100% *       | 100%         |
| Fine Leak  | 1014               | A $5 \times 10^{-8}$ atm-cc/sec           | 100% *       | 100%         |
| Gross Leak   | 1014               | C2 Fluorocarbon                           | 100% *       | 100%         |
| Electrical Test<br>Subgroups 1 and 7               | 5004               | See below for<br>definitions of subgroups | 100%         | 100%         |
| Insert Additional Screening here for Class B Parts |                    |   |              |              |
| Group A Sample Tests                               |                    |   |              |              |
| Subgroup 1   |                    |   | LTPD = 5     | LTPD = 5     |
| Subgroup 2   |                    |   | LTPD = 7     | LTPD = 7     |
| Subgroup 3   |                    |   | LTPD = 7     | LTPD = 7     |
| Subgroup 7   | 5005               | See below for<br>definitions of subgroups | LTPD = 7     | LTPD = 7     |
| Subgroup 8   |                    | Maximum accept number<br>is 3             | LTPD = 7     | LTPD = 7     |
| Subgroup 9   |                    |   | LTPD = 7     | LTPD = 7     |

\*Not applicable for Am2914PC.

## ORDERING INFORMATION

Order the part number according to the table below to obtain the desired package, temperature range, and screening level.

| Order Number | Package Type<br>(Note 1) | Operating Range<br>(Note 2) | Screening Level<br>(Note 3)                          |
|--------------|--------------------------|-----------------------------|--|
| AM2914PC     | P-40                     | C                           | C-1  |
| AM2914DC     | D-40                     | C                           | C-1  |
| AM2914DC-B   | D-40                     | C                           | B-2 (Note 4)   |
| AM2914DM     | D-40                     | M                           | C-3  |
| AM2914DM-B   | D-40                     | M                           | B-3  |
| AM2914FM     | F-42                     | M                           | C-3  |
| AM2914FM-B   | F-42                     | M                           | B-3  |
| AM2914XC     | Dice                     | C                           | Visual inspection<br>to MIL-STD-883<br>Method 2010B. |
| AM2914XM     | Dice                     | M                           |  |

Notes: 1. P = Molded DIP, D = Hermetic DIP, F = Flat Pak. Number following letter is number of leads. See Appendix B for detailed outline. Where Appendix B contains several dash numbers, any of the variations of the package may be used unless otherwise specified.

2. C = 0°C to +70°C, V<sub>CC</sub> = 4.75V to 5.25V, M = -55°C to +125°C, V<sub>CC</sub> = 4.50V to 5.50V.

3. See Appendix A for details of screening. Levels C-1 and C-3 conform to MIL-STD-883, Class C. Level B-3 conforms to MIL-STD-883, Class B.

4. 96 hour burn-in.

**MAXIMUM RATINGS** (Above which the useful life may be impaired)

|   |                                |
|---|--------------------------------|
| Storage Temperature                                 | −65°C to +150°C                |
| Temperature (Ambient) Under Bias                    | −55°C to +125°C                |
| Supply Voltage to Ground Potential                  | −0.5V to +7.0V                 |
| DC Voltage Applied to Outputs for High Output State | +0.5V to +V <sub>CC</sub> max. |
| DC Input Voltage                                    | −0.5V to 5.5V                  |
| DC Output Current, Into Outputs                     | 30mA                           |
| DC Input Current                                    | −30mA to +5.0mA                |

**OPERATING RANGE**

| P/N          | Temperature     | V <sub>CC</sub> |
|--------------|-----------------|-----------------|
| Am2914PC, DC | 0°C to +70°C    | 4.75V to 5.25V  |
| Am2914DM, FM | −55°C to +125°C | 4.50V to 5.50V  |

**ELECTRICAL CHARACTERISTICS OVER OPERATING TEMPERATURE RANGE** (Unless Otherwise Noted)

(Group A, Subgroups 1, 2, and 3)

|          |                                  |                                     |              |              |
|----------|----------------------------------|-------------------------------------|--------------|--------------|
| Am2914XC | T <sub>A</sub> = 0°C to +70°C    | V <sub>CC</sub> = 5.0V ± 5% (COM'L) | MIN. = 4.75V | MAX. = 5.25V |
| Am2914XM | T <sub>C</sub> = −55°C to +125°C | V <sub>CC</sub> = 5.0V ± 10% (MIL)  | MIN. = 4.50V | MAX. = 5.50V |

| Parameters       | Description                           | Test Conditions (Note 1)  |  | Min.       | Typ.<br>(Note 2) | Max.                                    | Units |
|------------------|---------------------------------------|---|--|------------|------------------|---|-------|
| V <sub>OH</sub>  | Output HIGH Voltage                   | V <sub>CC</sub> = MIN.,<br>V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub> | MIL, I <sub>OH</sub> = −1.0mA<br>COM'L, I <sub>OH</sub> = −2.6mA                                   | 2.4<br>2.4 |                  |   | Volts |
| I <sub>CEX</sub> | Output Leakage Current for IR Output  | V <sub>CC</sub> = MIN., V <sub>O</sub> = 5.5V                                   |  |            |                  | 250                                     | μA    |
| V <sub>OL</sub>  | Output LOW Voltage                    | V <sub>CC</sub> = MIN.,<br>V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub> | I <sub>OL</sub> = 4.0mA<br>I <sub>OL</sub> = 8.0mA<br>I <sub>OL</sub> = 12mA                       |            |                  | 0.4<br>0.45<br>0.5                      | Volts |
| V <sub>IH</sub>  | Input HIGH Level                      | Guaranteed input logical HIGH voltage for all inputs                            |  | 2.0        |                  |   | Volts |
| V <sub>IL</sub>  | Input LOW Level                       | Guaranteed input logical LOW voltage for all inputs                             |  |            |                  | 0.8                                     | Volts |
| V <sub>I</sub>   | Input Clamp Voltage                   | V <sub>CC</sub> = MIN., I <sub>IN</sub> = −18mA                                 |  |            |                  | −1.5                                    | Volts |
| I <sub>IL</sub>  | Input LOW Current                     | V <sub>CC</sub> = MAX.,<br>V <sub>IN</sub> = 0.4V                               | M0-7<br>S0-2<br>L. B.<br>I. D.<br>All Others   |            |                  | −0.15<br>−0.1<br>−0.4<br>−2.0<br>−0.8   | mA    |
| I <sub>IH</sub>  | Input HIGH Current                    | V <sub>CC</sub> = MAX.,<br>V <sub>IN</sub> = 2.7V                               | M0-7<br>S0-2<br>IE, GE, GAR<br>I. D.<br>All Others   |            |                  | 150<br>100<br>40<br>60<br>20            | μA    |
| I <sub>I</sub>   | Input HIGH Current                    | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 5.5V                                  |  |            |                  | 1.0                                     | mA    |
| I <sub>O</sub>   | Off-State Output Current              | V <sub>CC</sub> = MAX.  | V <sub>OUT</sub> = 0.5V<br>M0-7<br>S0-2<br>V0-2<br>V <sub>OUT</sub> = 2.4V<br>M0-7<br>S0-2<br>V0-2 |            |                  | −150<br>−100<br>−50<br>150<br>100<br>50 | μA    |
| I <sub>CC</sub>  | Power Supply Current                  | V <sub>CC</sub> = 5.0V, 25°C  |  |            | 170              | —                                       | mA    |
|                  |                                       | V <sub>CC</sub> = MAX.  | COM'L  | 0°C        |                  | 305                                     |       |
|                  |                                       |   |  | 70°C       |                  | 250                                     |       |
|                  |                                       |   | MIL  | −55°C      |                  | 310                                     |       |
| I <sub>SC</sub>  | Output Short Circuit Current (Note 3) | V <sub>CC</sub> = MAX.  |  | −30        |                  | −85                                     | mA    |

- Notes: 1. For conditions shown as MIN. or MAX., use the appropriate value specified under Electrical Characteristics for the applicable device type.  
 2. Typical limits are at V<sub>CC</sub> = 5.0V, 25°C ambient and maximum loading.  
 3. Not more than one output should be shorted at a time. Duration of the short circuit test should not exceed one second.



## SWITCHING CHARACTERISTICS AT 25°C AND 5.0 VOLTS

Note: Guaranteed limits at 25°C and 5.0V are group A, subgroup 9 tests

All outputs fully loaded.  $C_L = 50\text{pF}$ . Measurements made at 1.5V with input levels of 0V and 3.0V. All numbers are in ns.For interrupt request output,  $R_L = 470\Omega$ 

TABLE I. CLOCK AND INTERRUPT INPUT PULSE WIDTHS (ns)

| Time  | GUARANTEED |
|---|------------|
| Minimum Clock LOW Time  | 30         |
| Minimum Clock HIGH Time   | 30         |
| Minimum Interrupt Input (P <sub>0</sub> -P <sub>7</sub> ) LOW Time for Guaranteed Acceptance (Pulse Mode) | 25         |
| Maximum Interrupt Input (P <sub>0</sub> -P <sub>7</sub> ) LOW Time for Guaranteed Rejection (Pulse Mode)  | 10         |

2

TABLE II. COMBINATIONAL PROPAGATION DELAYS (ns)

| From Input \ To Output | TYPICAL |       |                  |          |                |                    | GUARANTEED |       |                  |          |                |                    |
|------------------------|---------|-------|------------------|----------|----------------|--------------------|------------|-------|------------------|----------|----------------|--------------------|
|                        | M Bus   | S Bus | V <sub>012</sub> | Irpt Req | Ripple Disable | Group Advance Send | M Bus      | S Bus | V <sub>012</sub> | Irpt Req | Ripple Disable | Group Advance Send |
| $\overline{IE}$        | 36      | 40    | 40               | —        | —              | 30                 | 48         | 55    | 55               | —        | —              | 47                 |
| I <sub>0123</sub>      | 36      | 40    | 40               | —        | —              | 30                 | 48         | 55    | 55               | —        | —              | 47                 |
| Irpt. Disable          | —       | —     | 25               | 35       | 8              | 19                 | —          | —     | 37               | 42       | 18             | 25                 |

TABLE III. DELAYS FROM CLOCK TO OUTPUTS (ns)

| Clock Path                     | TYPICAL             |             |       |                    |                     |                  |                    | GUARANTEED          |             |       |                    |                     |                  |                    |
|--------------------------------|---------------------|-------------|-------|--------------------|---------------------|------------------|--------------------|---------------------|-------------|-------|--------------------|---------------------|------------------|--------------------|
|                                | To V <sub>012</sub> | To Irpt Req | To PD | To $\overline{RD}$ | To $\overline{GAS}$ | To Status O'flow | To $\overline{GS}$ | To V <sub>012</sub> | To Irpt Req | To PD | To $\overline{RD}$ | To $\overline{GAS}$ | To Status O'flow | To $\overline{GS}$ |
| Irpt Latches and Register      | 55                  | 65          | 37    | 39                 | 47                  | —                | —                  | 67                  | 82          | 57    | 57                 | 66                  | —                | —                  |
| Mask Register                  | 55                  | 65          | 37    | 39                 | 47                  | —                | —                  | 67                  | 82          | 57    | 57                 | 66                  | —                | —                  |
| Status Register                | 45                  | 55          | 28    | 31                 | 37                  | —                | —                  | 59                  | 74          | 57    | 57                 | 58                  | —                | —                  |
| Lowest Group Enabled Flip-Flop | —                   | —           | 22    | 25                 | —                   | —                | 17                 | —                   | —           | 42    | 45                 | —                   | —                | 32                 |
| Irpt Request Enable Flip-Flop  | —                   | 40          | —     | —                  | —                   | —                | —                  | —                   | 56          | —     | —                  | —                   | —                | —                  |
| Status Overflow Flip-Flop      | —                   | —           | —     | —                  | —                   | 17               | —                  | —                   | —           | —     | —                  | —                   | 30               | —                  |

TABLE IV. SET-UP AND HOLD TIME REQUIREMENTS (ns)

(All relative to clock LOW-to-HIGH transition)

| From Input  | GUARANTEED     |           |
|---|----------------|-----------|
|   | Set-up Time    | Hold Time |
| S-Bus   | 11             | 8         |
| M-Bus   | 11             | 8         |
| P <sub>0</sub> -P <sub>7</sub>                          | 11             | 6         |
| Latch Bypass  | 16             | 0         |
| $\overline{IE}$   | 46             | 0         |
| I <sub>0123</sub> (See Note)                            | $t_{pwL} + 29$ | 0         |
| $\overline{GE}$   | 11             | 11        |
| $\overline{GAR}$  | 11             | 11        |
| Irpt Disable  | 35             | 0         |
| P <sub>0</sub> -P <sub>7</sub> Hold Time Relative to LB | —              | 21        |

Note:  $t_{pwL}$  is the Clock LOW Time. Both Set-up times must be met.

TABLE V. CLOCK AND INTERRUPT INPUT PULSE WIDTHS (ns)

| Time  | Am2914PC, DC, XC<br>$T_A = 0^\circ\text{C to } +70^\circ\text{C}, 5V \pm 5\%$ | Am2914DM, FM, XM<br>$T_C = -55^\circ\text{C to } +125^\circ\text{C}, 5V \pm 10\%$ |
|---|---|---|
| Minimum Clock LOW Time  | 30  | 30  |
| Minimum Clock HIGH Time   | 30  | 30  |
| Minimum Interrupt Input ( $P_0$ - $P_7$ )<br>LOW Time for Guaranteed<br>Acceptance (Pulse Mode) | 40  | 40  |
| Maximum Interrupt Input ( $P_0$ - $P_7$ )<br>LOW Time for Guaranteed<br>Rejection (Pulse Mode)  | 8   | 8   |
| Minimum Clock Period, $\overline{IE} = H$ on<br>current cycle and previous cycle                | 50  | 55  |
| Minimum Clock Period, $\overline{IE} = L$ on<br>current cycle or previous cycle                 | 100   | 110   |

TABLE VI. MAXIMUM COMBINATIONAL PROPAGATION DELAYS (ns)

|                 |           | Am2914PC, DC, XC<br>$T_A = 0^\circ\text{C to } +70^\circ\text{C}, 5V \pm 5\%$ |       |           |          |                |                    | Am2914DM, FM, XM<br>$T_C = -55^\circ\text{C to } +125^\circ\text{C}, 5V \pm 10\%$ |       |           |          |                |                    |
|-----------------|-----------|---|-------|-----------|----------|----------------|--------------------|---|-------|-----------|----------|----------------|--------------------|
| From Input      | To Output | M Bus   | S Bus | $V_{012}$ | Irpt Req | Ripple Disable | Group Advance Send | M Bus   | S Bus | $V_{012}$ | Irpt Req | Ripple Disable | Group Advance Send |
|                 |           |   |       |           |          |                |                    |   |       |           |          |                |                    |
| $\overline{IE}$ |           | 52  | 60    | 65        | —        | —              | 56                 | 60  | 68    | 70        | —        | —              | 62                 |
| $I_{0123}$      |           | 52  | 60    | 65        | —        | —              | 56                 | 60  | 68    | 70        | —        | —              | 62                 |
| Irpt. Disable   |           | —   | —     | 45        | 52       | 20             | 30                 | —   | —     | 48        | 60       | 22             | 33                 |

TABLE VII. MAXIMUM DELAYS FROM CLOCK TO OUTPUTS (ns)

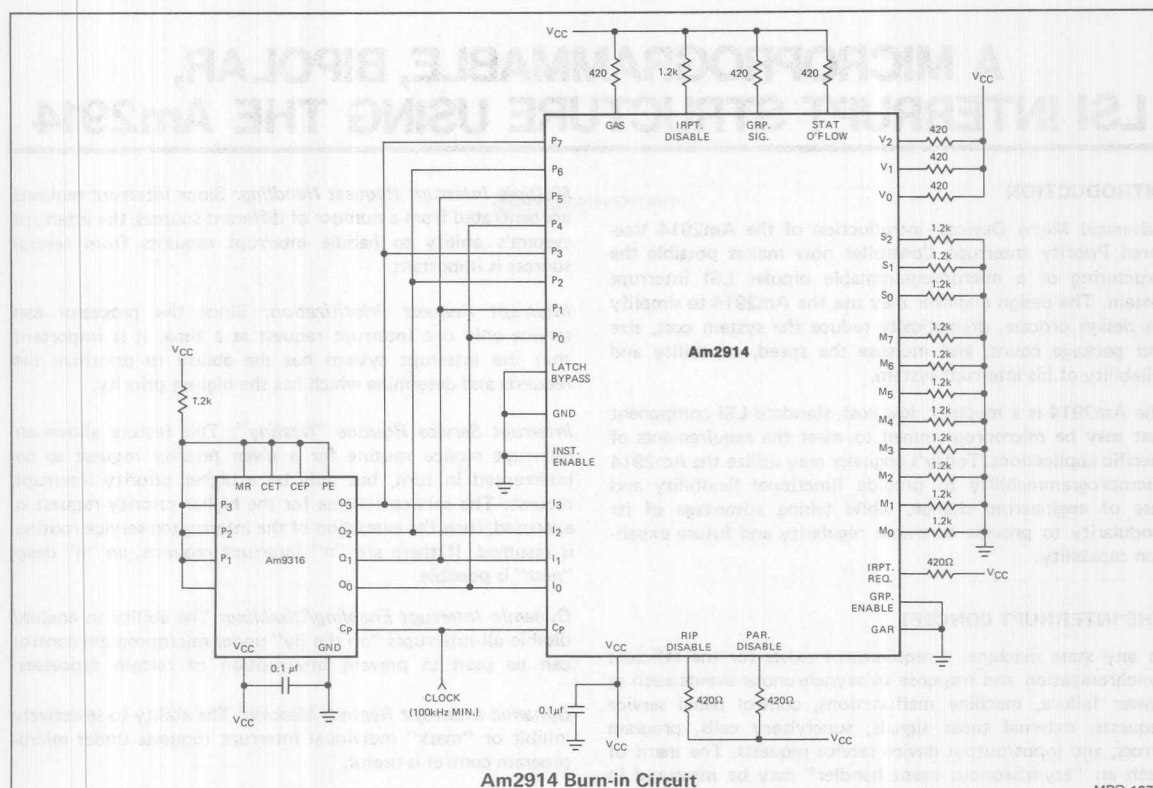
| Clock Path                     | Am2914PC, DC, XC<br>$T_A = 0^\circ\text{C to } +70^\circ\text{C}, 5V \pm 5\%$ |             |       |                    |                     |                  |                    |  | Am2914DM, FM, XM<br>$T_C = -55^\circ\text{C to } +125^\circ\text{C}, 5V \pm 10\%$ |             |       |                    |                     |                  |                    |  |
|--------------------------------|---|-------------|-------|--------------------|---------------------|------------------|--------------------|--|---|-------------|-------|--------------------|---------------------|------------------|--------------------|--|
|                                | To $V_{012}$  | To Irpt Req | To PD | To $\overline{RD}$ | To $\overline{GAS}$ | To Status O'flow | To $\overline{GS}$ |  | To $V_{012}$  | To Irpt Req | To PD | To $\overline{RD}$ | To $\overline{GAS}$ | To Status O'flow | To $\overline{GS}$ |  |
| Irpt Latches and Register      | 76  | 97          | 67    | 67                 | 80                  | —                | —                  |  | 82  | 105         | 75    | 75                 | 85                  | —                | —                  |  |
| Mask Register                  | 76  | 97          | 67    | 67                 | 80                  | —                | —                  |  | 82  | 105         | 75    | 75                 | 85                  | —                | —                  |  |
| Status Register                | 67  | 88          | 63    | 63                 | 70                  | —                | —                  |  | 73  | 96          | 66    | 66                 | 76                  | —                | —                  |  |
| Lowest Group Enabled Flip-Flop | —   | —           | 48    | 52                 | —                   | —                | 38                 |  | —   | 54          | 58    | —                  | —                   | —                | 45                 |  |
| Irpt Request Enable Flip-Flop  | —   | 62          | —     | —                  | —                   | —                | —                  |  | 66  | —           | —     | —                  | —                   | —                | —                  |  |
| Status Overflow Flip-Flop      | —   | —           | —     | —                  | —                   | 35               | —                  |  | —   | —           | —     | —                  | —                   | 40               | —                  |  |

TABLE VIII. SET-UP AND HOLD TIME REQUIREMENTS (ns)

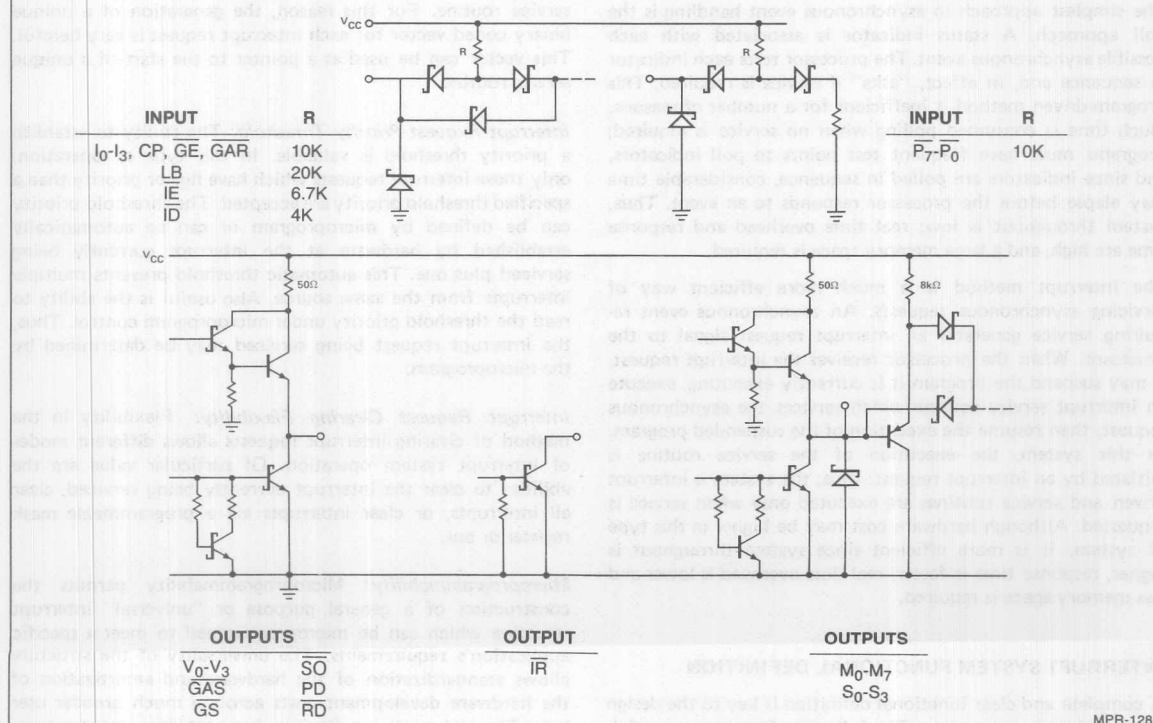
(All relative to clock LOW-to-HIGH transition)

| From Input                                | Am2914PC, DC, XC<br>$T_A = 0^\circ\text{C to } +70^\circ\text{C}, 5V \pm 5\%$ |           | Am2914DM, FM, XM<br>$T_C = -55^\circ\text{C to } +125^\circ\text{C}, 5V \pm 10\%$ |           |
|---|---|-----------|---|-----------|
|   | Set-Up Time   | Hold Time | Set-Up Time   | Hold Time |
| S-Bus                                     | 15  | 10        | 15  | 10        |
| M-Bus                                     | 15  | 10        | 15  | 10        |
| $\overline{P_0}$ - $\overline{P_7}$       | 15  | 8         | 15  | 8         |
| Latch Bypass                              | 20  | 0         | 20  | 0         |
| $\overline{IE}$                           | 55  | 0         | 55  | 0         |
| $I_{0123}$ (See Note)                     | $t_{pwL} + 33$  | 0         | $t_{pwL} + 40$  | 0         |
| $\overline{GE}$                           | 15  | 13        | 15  | 13        |
| $\overline{GAS}$                          | 15  | 13        | 15  | 13        |
| Irpt Disable                              | 42  | 0         | 42  | 0         |
| $P_0$ - $P_7$ Hold Time<br>Relative to LB | —   | 25        | —   | 25        |

Note:  $t_{pwL}$  is the Clock LOW Time. Both Set-up times must be met.



## INPUT/OUTPUT CIRCUITS



# A MICROPROGRAMMABLE, BIPOLAR, LSI INTERRUPT STRUCTURE USING THE Am2914

## INTRODUCTION

Advanced Micro Devices' introduction of the Am2914 Vectored Priority Interrupt Controller now makes possible the structuring of a microprogrammable bipolar LSI interrupt system. The design engineer may use the Am2914 to simplify his design process, dramatically reduce the system cost, size and package count, and increase the speed, capability and reliability of his interrupt system.

The Am2914 is a modular, low cost, standard LSI component that may be microprogrammed to meet the requirements of specific applications. Today's engineer may utilize the Am2914 microprogrammability to provide functional flexibility and ease of engineering change, while taking advantage of its modularity to provide hardware regularity and future expansion capability.

## THE INTERRUPT CONCEPT

In any state machine, a requirement exists for the efficient synchronization and response to asynchronous events such as power failure, machine malfunctions, control panel service requests, external timer signals, supervisory calls, program errors, and input/output device service requests. The merit of such an "asynchronous event handler" may be measured in terms of response time, system throughput, real time overhead, hardware cost and memory space required.

The simplest approach to asynchronous event handling is the poll approach. A status indicator is associated with each possible asynchronous event. The processor tests each indicator in sequence and, in effect, "asks" if service is required. This program-driven method is inefficient for a number of reasons. Much time is consumed polling when no service is required; programs must have frequent test points to poll indicators, and since indicators are polled in sequence, considerable time may elapse before the processor responds to an event. Thus, system throughput is low; real time overhead and response time are high, and a large memory space is required.

The interrupt method is a much more efficient way of servicing asynchronous requests. An asynchronous event requiring service generates an interrupt request signal to the processor. When the processor receives the interrupt request, it may suspend the program it is currently executing, execute an interrupt service routine which services the asynchronous request, then resume the execution of the suspended program. In this system, the execution of the service routine is initiated by an interrupt request; thus, the system is interrupt driven and service routines are executed only when service is requested. Although hardware cost may be higher in this type of system, it is more efficient since system throughput is higher, response time is faster, real time overhead is lower and less memory space is required.

## INTERRUPT SYSTEM FUNCTIONAL DEFINITION

A complete and clear functional definition is key to the design of a good interrupt system. The following features are useful.

**Multiple Interrupt Request Handling:** Since interrupt requests are generated from a number of different sources, the interrupt system's ability to handle interrupt requests from several sources is important.

**Interrupt Request Prioritization:** Since the processor can service only one interrupt request at a time, it is important that the interrupt system has the ability to prioritize the requests and determine which has the highest priority.

**Interrupt Service Routine "Nesting":** This feature allows an interrupt service routine for a given priority request to be interrupted in turn, but only by a higher priority interrupt request. The service routine for the higher priority request is executed, then the execution of the interrupted service routine is resumed. If there are "n" interrupt requests, an "n" deep "nest" is possible.

**Dynamic Interrupt Enabling/Disabling:** The ability to enable/disable all interrupts "on the fly" under microprogram control can be used to prevent interruption of certain processes.

**Dynamic Interrupt Request Masking:** The ability to selectively inhibit or "mask" individual interrupt requests under microprogram control is useful.

**Interrupt Request Vectoring:** Many times, a particular interrupt request requires the execution of a unique interrupt service routine. For this reason, the generation of a unique binary coded vector for each interrupt request is very helpful. This vector can be used as a pointer to the start of a unique service routine.

**Interrupt Request Priority Threshold:** The ability to establish a priority threshold is valuable. In this type of operation, only those interrupt requests which have higher priority than a specified threshold priority are accepted. The threshold priority can be defined by microprogram or can be automatically established by hardware at the interrupt currently being serviced plus one. This automatic threshold prevents multiple interrupts from the same source. Also useful is the ability to read the threshold priority under microprogram control. Thus, the interrupt request being serviced may be determined by the microprogram.

**Interrupt Request Clearing Flexibility:** Flexibility in the method of clearing interrupt requests allows different modes of interrupt system operation. Of particular value are the abilities to clear the interrupt currently being serviced, clear all interrupts, or clear interrupts via a programmable mask register or bus.

**Microprogrammability:** Microprogrammability permits the construction of a general purpose or "universal" interrupt structure which can be microprogrammed to meet a specific application's requirements. The universality of the structure allows standardization of the hardware and amortization of the hardware development costs across a much broader user base. The end result is a flexible, low cost interrupt structure.



**Hardware Modularity:** Modular interrupt system hardware is beneficial in two ways. First, hardware modularity provides expansion capability. Additional modules may be added as the need to service additional requests arises. Secondly, hardware modularity provides a structural regularity which simplifies the system structure and also reduces the number of hardware part numbers.

**Fast Interrupt System Response Time:** Quick interrupt system response provides more efficient system operation. Fast response reduces real time overhead and increases overall system throughput.

## INTERRUPT SYSTEM IMPLEMENTATION USING THE Am2914

The Am2914 provides all of the foregoing features on a single LSI chip. The Am2914 is a high-speed, eight-bit priority interrupt unit that is cascadable to handle any number of priority interrupt request levels. The Am2914's high speed is ideal for use in Am2900 Family microcomputer designs, but it can also be used with the Am9080A MOS microprocessor.

The Am2914 receives interrupt requests on eight Interrupt Input lines (P<sub>0</sub>-P<sub>7</sub>). A LOW level is a request. An internal latch may be used to catch pulses (HIGH-LOW-HIGH) on these lines, or the latch may be bypassed so that the request lines drive the D-inputs to the edge-triggered Interrupt Register directly. An eight-bit Mask Register is used to mask individual interrupts. Considerable flexibility is provided for controlling the Mask Register. Requests in the Interrupt Register (P<sub>0</sub>-P<sub>7</sub>) are ANDed with the corresponding bits in the mask register (M<sub>0</sub>-M<sub>7</sub>) and the results are sent to an eight-input priority encoder, which produces a three-bit encoded vector representing the highest priority input which is not masked.

An internal Status Register is used to point to the lowest priority at which an interrupt will be accepted. The contents of the Status Register are compared with the output of the

priority encoder, and an Interrupt Request output will occur if the vector is greater than or equal to the contents of the Status Register. Whenever a vector is read from the Am2914, the Status Register is automatically updated to point to one level higher than the vector read. (The Status Register can be loaded externally or read out at any time using the S-Bus.) Signals are provided for moving the status upward across devices (Group Advance Send and Group Advance Receive) and for inhibiting lower priorities from higher order devices (Ripple Disable, Parallel Disable, and Interrupt Disable). A Status Overflow output indicates that an interrupt has been read at the highest priority.

The Am2914 is controlled by a four-bit microinstruction field I<sub>0</sub>-I<sub>3</sub>. The microinstruction is executed if I<sub>E</sub> (Instruction Enable) is LOW and is ignored if I<sub>E</sub> is HIGH, allowing the four I bits to be shared with other functions. Sixteen different microinstructions are executed. Figure 2 shows the microinstructions and the microinstruction codes.

| MICROINSTRUCTION DESCRIPTION        | MICROINSTRUCTION CODE                                       |
|-------------------------------------|---|
|                                     | I <sub>3</sub> I <sub>2</sub> I <sub>1</sub> I <sub>0</sub> |
| MASTER CLEAR                        | 0000  |
| CLEAR ALL INTERRUPTS                | 0001  |
| CLEAR INTERRUPTS FROM M-BUS         | 0010  |
| CLEAR INTERRUPTS FROM MASK REGISTER | 0011  |
| CLEAR INTERRUPT, LAST VECTOR READ   | 0100  |
| READ VECTOR                         | 0101  |
| READ STATUS REGISTER                | 0110  |
| READ MASK REGISTER                  | 0111  |
| SET MASK REGISTER                   | 1000  |
| LOAD STATUS REGISTER                | 1001  |
| BIT CLEAR MASK REGISTER             | 1010  |
| BIT SET MASK REGISTER               | 1011  |
| CLEAR MASK REGISTER                 | 1100  |
| DISABLE INTERRUPT REQUEST           | 1101  |
| LOAD MASK REGISTER                  | 1110  |
| ENABLE INTERRUPT REQUEST            | 1111  |

Figure 2. Am2914 Microinstruction Set.

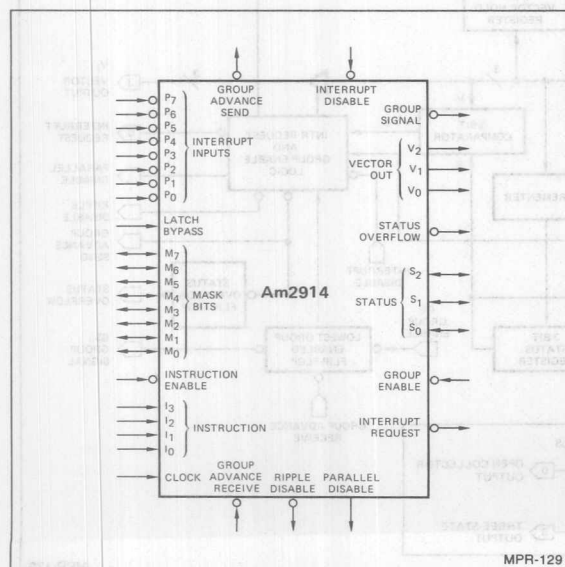


Figure 1. Am2914 Logic Symbol.

In this microinstruction set, the *Master Clear* microinstruction is selected as binary zero so that during a power up sequence, the microinstruction register in the microprogram control unit of the central processor can be cleared to all zeros. Thus, on the next clock cycle, the Am2914 will execute the *Master Clear* function. This includes clearing the Interrupt Latches and Register as well as the Mask Register and Status Register. The LGE flip-flop of the least significant group is set LOW because the Group Advance Receive input is tied LOW. All other Group Advance Receive inputs are tied to Group Advance Send outputs and these are forced HIGH during this instruction. This clear instruction also sets the Interrupt Request Enable flip-flop so that a fully interrupt driven system can be easily initiated from any interrupt.

The *Clear Interrupts from Mask Register* microinstruction clears those Interrupt Latches and Register bits which have corresponding Mask Register bits set equal to one. The M-Bus is used by the Am2914 during the execution of this microinstruction and must be floating.

The *Clear Interrupts from M-Bus* microinstruction clears those Interrupt Latches and Register bits which have corresponding M-Bus bits set equal to one.

The *Clear Interrupt, Last Vector Read* microinstruction clears the Interrupt Latch and Register bit associated with the last vector read.

The *Read Vector* microinstruction is used to read the vector value of the highest priority request causing the interrupt. The vector outputs are three-state drivers that are enabled onto the  $V_0V_1V_2$  bus during this instruction. This microinstruction also automatically loads the value "vector plus one" into the Status Register. In addition, this instruction sets the Vector Clear Enable flip-flop and loads the current vector value into the Vector Hold Register so that this value can be used by the *Clear Interrupt, Last Vector Read* microinstruction. This allows the user to read the vector associated with the interrupt, and at some later time clear the Interrupt Latch and Register bit associated with the vector read.

The *Load Status Register* microinstruction loads S-Bus data into the Status Register and also loads the LGE flip-flop from the Group Enable input.

The Status Bus is a three-bit, bi-directional, three-state bus.

The *Load Mask Register* microinstruction loads data from the three-state, bi-directional M-Bus into the Mask Register.

The *Read Mask Register* microinstruction enables the Mask Register outputs onto the bi-directional, three-state M-Bus.

The *Set Mask Register* microinstruction sets all the bits in the Mask Register to one. This results in all interrupts being inhibited.

The entire Mask Register is cleared by the *Clear Mask Register* microinstruction. This enables all interrupts subject to the Interrupt Enable flip-flop and the Status Register.

The *Bit Clear Mask Register* microinstruction may be used to selectively clear individual Mask Register bits. This microinstruction clears those Mask Register bits which have corresponding M-Bus bits equal to one. Mask Register bits with corresponding M-Bus bits equal to zero are not affected.

The *Bit Set Mask Register* microinstruction sets those Mask Register bits which have corresponding M-Bus bits equal to one. Other Mask Register bits are not affected.

All Interrupt Requests may be disabled by execution of the *Disable Interrupt Request* microinstruction. This microinstruction resets an Interrupt Request Enable flip-flop on the chip.

The *Enable Interrupt Request* microinstruction sets the Interrupt Enable flip-flop. Thus, Interrupt Requests are enabled subject to the contents of the Mask and Status Registers.

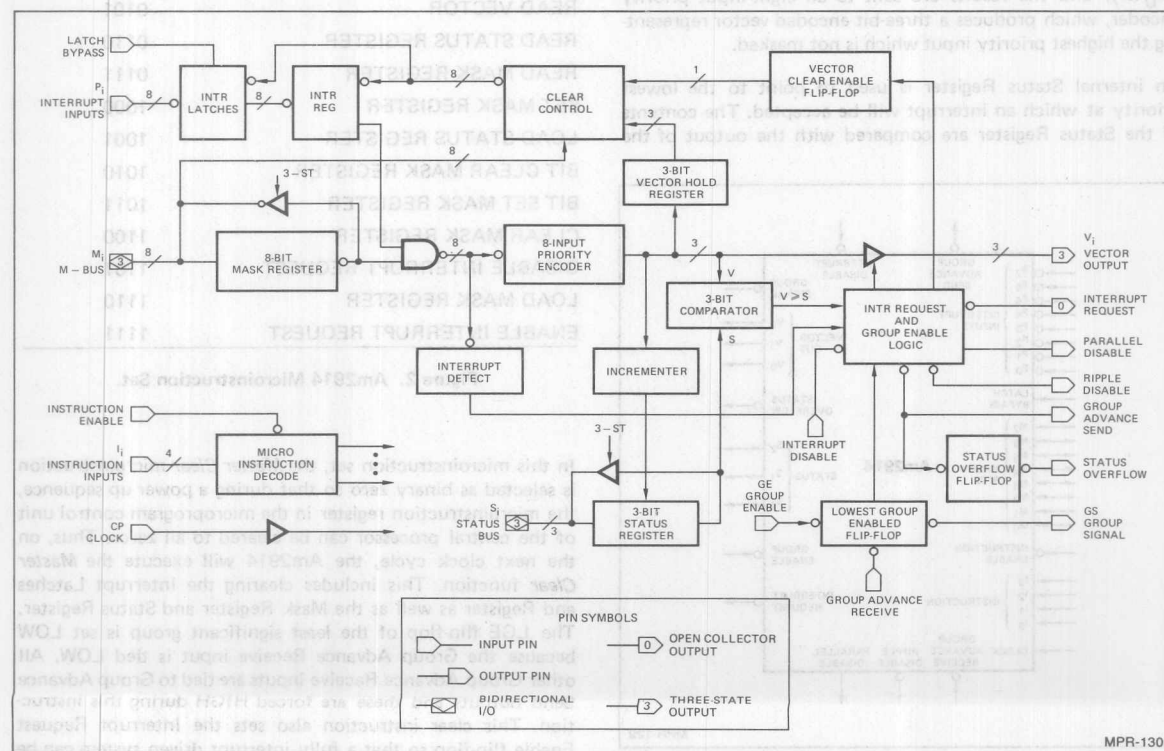


Figure 3. Am2914 Block Diagram.

### Am2914 BLOCK DIAGRAM DESCRIPTION

The Am2914 block diagram is shown in Figure 3. The Microinstruction Decode circuitry decodes the Interrupt Microinstructions and generates required control signals for the chip.

The Interrupt Register holds the Interrupt Inputs and is an eight-bit, edge-triggered register which is set on the rising edge of the CP Clock signal if the Interrupt Input is LOW.

The Interrupt latches are set/reset latches. When the Latch Bypass signal is LOW, the latches are enabled and act as negative pulse catchers on the inputs to the Interrupt Register. When the Latch Bypass signal is HIGH, the Interrupt latches are transparent.

The Mask Register holds the eight mask bits associated with the eight interrupt levels. The register may be loaded from or read to the M-Bus. Also, the entire register or individual mask bits may be set or cleared.

The Interrupt Detect circuitry detects the presence of any unmasked Interrupt Input. The eight-input Priority Encoder determines the highest priority, non-masked Interrupt Input and forms a binary coded interrupt vector. Following a Vector Read, the three-bit Vector Hold Register holds the binary coded interrupt vector. This stored vector can be used later for clearing interrupts.

The three-bit Status Register holds the status bits and may be loaded from or read to the S-Bus. During a Vector Read, the Incrementer increments the interrupt vector by one, and the result is clocked into the Status Register. Thus, the Status Register points to a level one greater than the vector just read.

The three-bit Comparator compares the Interrupt Vector with the contents of the Status Register and indicates if the Interrupt Vector is greater than or equal to the contents of the Status Register.

The Lowest Group Enabled Flip-Flop is used when a number of Am2914's are cascaded. In a cascaded system, only one Lowest Group Enabled Flip-Flop is LOW at a time. It indicates the eight interrupt group, which contains the lowest priority interrupt level which will be accepted and is used to form the higher order status bits.

The Interrupt Request and Group Enable logic contain various gating to generate the Interrupt Request, Parallel Disable, Ripple Disable, and Group Advance Send signals.

The Status Overflow signal is used to disable all interrupts. It indicates the highest priority interrupt vector has been read and the Status Register has overflowed.

The Clear Control logic generates the eight individual clear signals for the bits in the Interrupt Latches and Register. The Vector Clear Enable Flip-Flop indicates if the last vector read was from this chip. When it is set it enables the Clear Control Logic.

The CP clock signal is used to clock the Interrupt Register, Mask Register, Status Register, Vector Hold Register, and the Lowest Group Enabled, Vector Clear Enable and Status Overflow Flip-Flops, all on the clock LOW-to-HIGH transition.

The Am2914 can be microprogrammed in many different ways. Figure 4 shows an example interrupt sequence. The *Read Vector* microinstruction is necessary in order to read the interrupt priority level. Since vector plus one is automatically loaded into the Status Register when a *Read Vector* microinstruction is executed, the Status Register possibly will overflow and disable all interrupts. For this reason, the Status

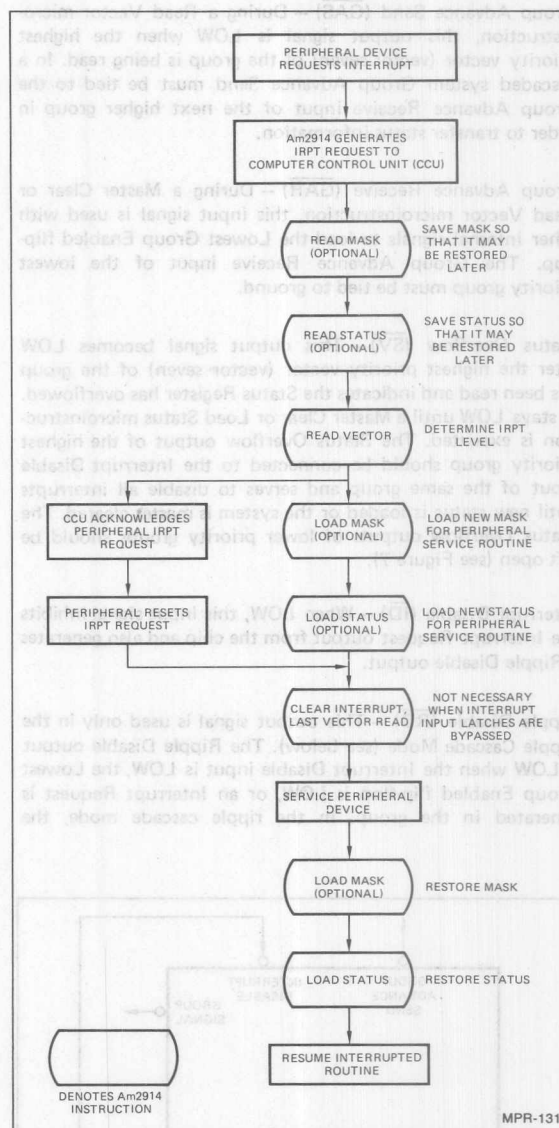


Figure 4. Example Interrupt Sequence.

Register must be reloaded periodically. The other Am2914 microinstructions are optional. **DESIGN**

## CASCADING THE Am2914

A number of input/output signals are provided for cascading the Am2914 Vectored Priority Interrupt Encoder. A definition of these I/O signals and their required connections follows:

Group Signal ( $\overline{GS}$ ) – This signal is the output of the Lowest Group Enabled flip-flop and during a Read Status micro-instruction is used to generate the high order bits of the Status word.

**Group Enable ( $\overline{GE}$ )** – This signal is one of the inputs to the Lowest Group Enable flip-flop and is used to load the flip-flop during the Load Status microinstruction.

## Am2914

**Group Advance Send ( $\overline{\text{GAS}}$ )** — During a Read Vector microinstruction, this output signal is LOW when the highest priority vector (vector seven) of the group is being read. In a cascaded system Group Advance Send must be tied to the Group Advance Receive input of the next higher group in order to transfer status information.

**Group Advance Receive ( $\overline{\text{GAR}}$ )** — During a Master Clear or Read Vector microinstruction, this input signal is used with other internal signals to load the Lowest Group Enabled flip-flop. The Group Advance Receive input of the lowest priority group must be tied to ground.

**Status Overflow ( $\overline{\text{SV}}$ )** — This output signal becomes LOW after the highest priority vector (vector seven) of the group has been read and indicates the Status Register has overflowed. It stays LOW until a Master Clear or Load Status microinstruction is executed. The Status Overflow output of the highest priority group should be connected to the Interrupt Disable input of the same group and serves to disable all interrupts until new status is loaded or the system is master cleared. The Status Overflow outputs of lower priority groups should be left open (see Figure 7).

**Interrupt Disable ( $\overline{\text{ID}}$ )** — When LOW, this input signal inhibits the Interrupt Request output from the chip and also generates a Ripple Disable output.

**Ripple Disable ( $\overline{\text{RD}}$ )** — This output signal is used only in the Ripple Cascade Mode (see below). The Ripple Disable output is LOW when the Interrupt Disable input is LOW, the Lowest Group Enabled flip-flop is LOW, or an Interrupt Request is generated in the group. In the ripple cascade mode, the

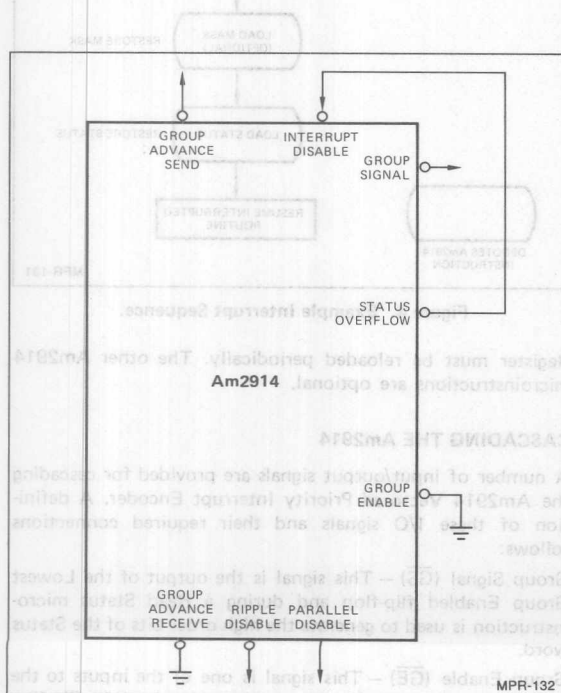


Figure 5. Cascade Lines Connection for Single Chip System.

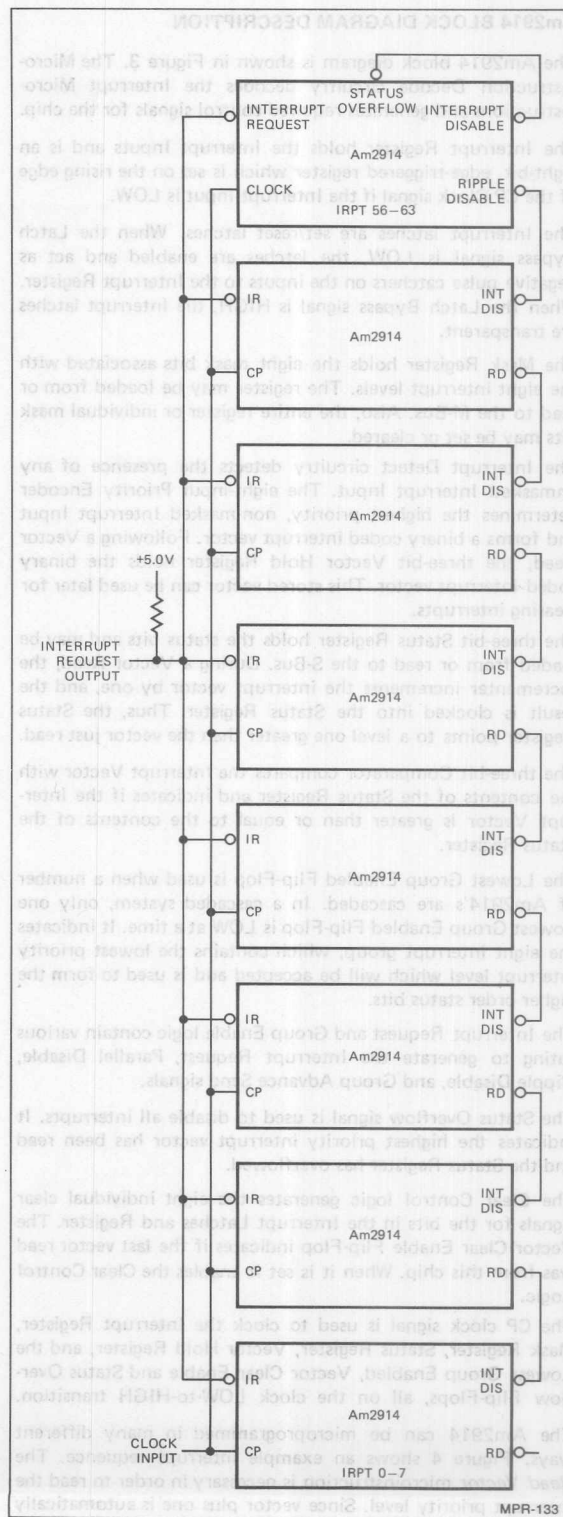


Figure 6. Interrupt Disable Connections for Ripple Cascade Mode.





**Figure 7. Interrupt Disable Connections for Parallel Cascade Mode.**

the next lower priority group (see Figure 6).

**Parallel Disable (PD)** — This output is used only in the parallel cascade mode (see below). It is HIGH when the Lowest Group Enabled flip-flop is LOW or an Interrupt Request is generated in the group. It is not affected by the Interrupt Disable input.

A single Am2914 chip may be used to prioritize and encode up to eight interrupt inputs. Figure 5 shows how the above cascade lines should be connected in such a single chip system.

The Group Advance Receive and Group Enable inputs should be connected to ground so that the Lowest Group Enabled flip-flop is forced LOW during a *Master Clear* or *Load Status* microinstruction. Status Overflow should be connected to Interrupt Disable in order to disable interrupts when vector seven is read. The Group Advance Send, Ripple Disable, Group Signal and Parallel Disable pins should be left open.

The Am2914 may be cascaded in either a Ripple Cascade Mode or a Parallel Cascade Mode. In the Ripple Cascade Mode, the Interrupt Disable signal, which disables lower priority interrupts, is allowed to ripple through lower priority groups. Figures 6, 9 and 11 show the cascade connections required for a ripple cascade 64 input interrupt system.

employed using the high-speed Am2902 Carry Look-Ahead Generator. Figures 7, 9 and 10 show the cascade connections required for a parallel-cascade 64-input interrupt system. For this application, the Am2902 is used as a lookahead interrupt disable generator. A Parallel Disable output from any group results in the disabling of all lower priority groups in parallel. Figure 8 shows the Am2902 logic diagram and equations.

In Figures 9 and 10, the Am2913 Priority Interrupt Expander is shown forming the high order bits of the vector and status, respectively. The Am2913 is an eight-line to three-line priority encoder with three-state outputs which are enabled by the five output control signals G1, G2,  $\overline{G3}$ ,  $\overline{G4}$ , and G5. In Figure 9, the Am2913 is connected so that its outputs are enabled during a Read Vector instruction, and in Figure 10 the Am2913 is connected so that its outputs are enabled during a Read Status instruction. The Am2913 logic diagram and truth table are shown in Figure 11.

The Am25LS138 three-line to eight-line Decoder also is shown in Figure 10. It is used to decode the three high order status bits during a Load Status instruction. The Am25LS138 logic diagram and truth table are shown in Figure 12.

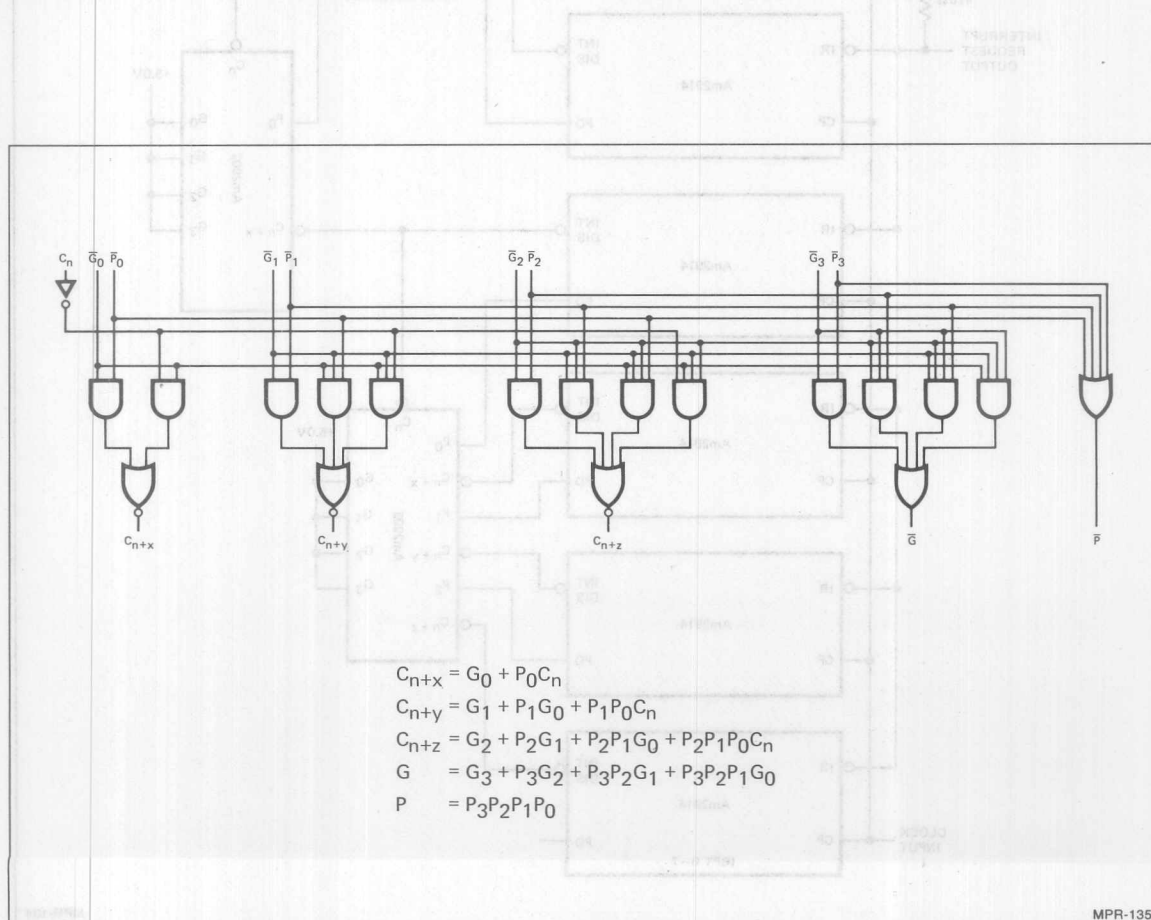
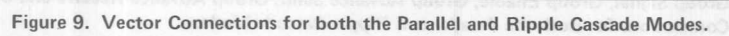
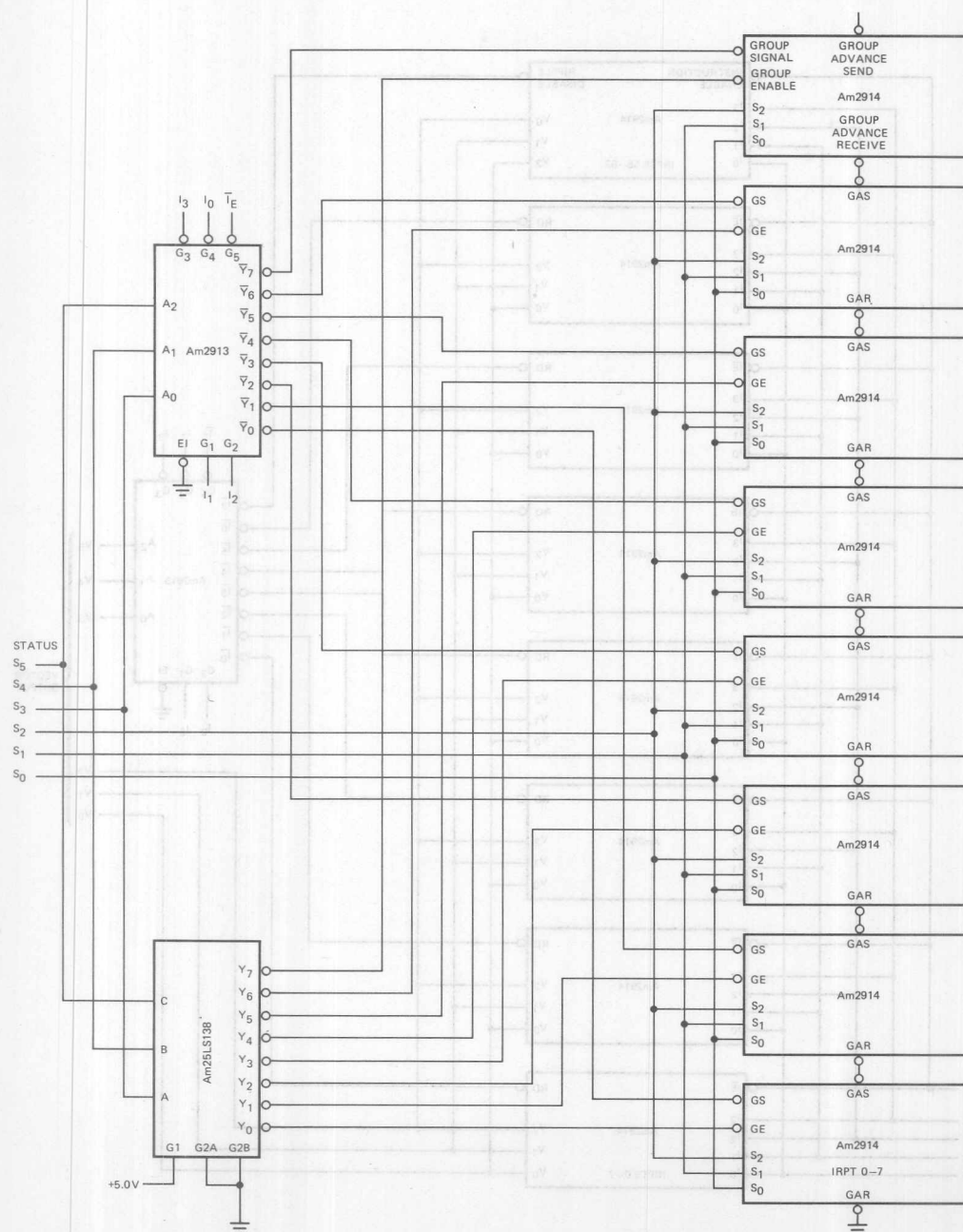


Figure 8. Am2902 Carry Look-Ahead Generator Logic Diagram and Equations.





MPR-137

Figure 10. Group Signal, Group Enable, Group Advance Send, Group Advance Receive and Status Connections for Both the Parallel and Ripple Cascade Modes.



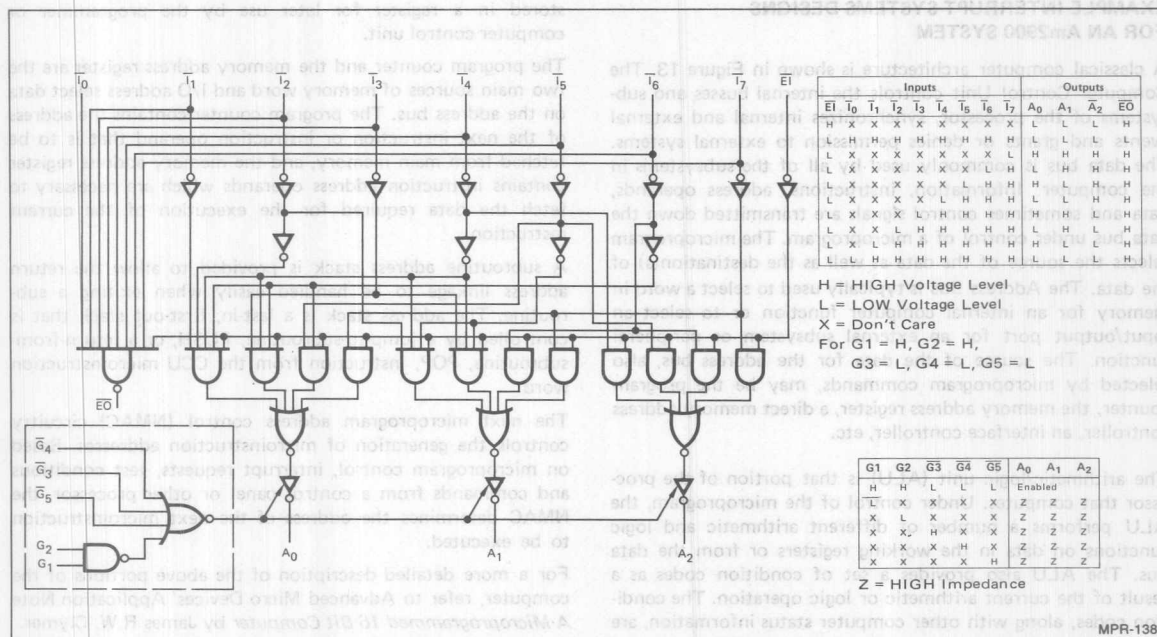


Figure 11. Am2913 Priority Interrupt Expander Logic Diagram and Truth Table.

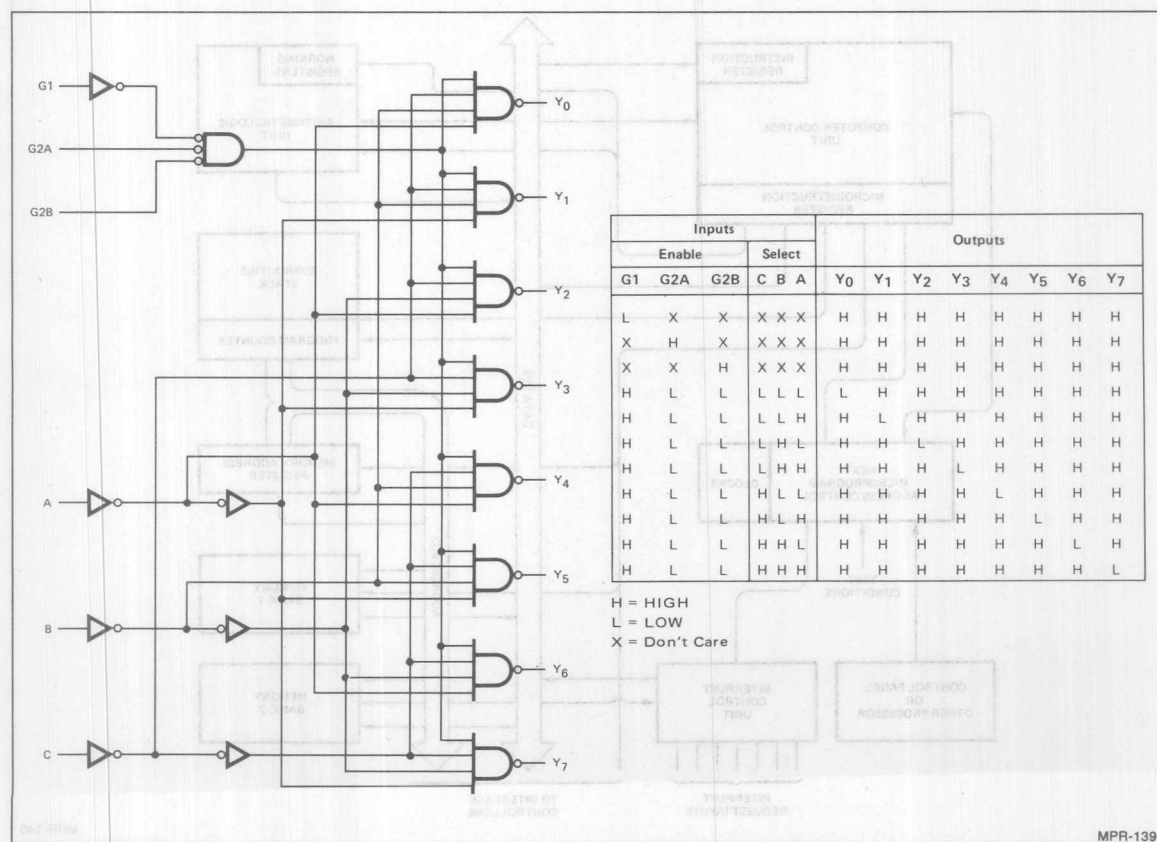


Figure 12. Am25LS138 3 to 8 Line Decoder Logic Diagram and Truth Table.

### EXAMPLE INTERRUPT SYSTEMS DESIGNS FOR AN Am2900 SYSTEM

A classical computer architecture is shown in Figure 13. The Computer Control Unit controls the internal busses and subsystems of the processor, synchronizes internal and external events and grants or denies permission to external systems. The data bus is commonly used by all of the subsystems in the computer. Information, instructions, address operands, data and sometimes control signals are transmitted down the data bus under control of a microprogram. The microprogram selects the source of the data as well as the destination(s) of the data. The Address Bus is typically used to select a word in memory for an internal computer function or to select an input/output port for an external subsystem or peripheral function. The source of the data for the address bus, also selected by microprogram commands, may be the program counter, the memory address register, a direct memory address controller, an interface controller, etc.

The arithmetic/logic unit (ALU) is that portion of the processor that computes. Under control of the microprogram, the ALU performs a number of different arithmetic and logic functions on data in the working registers or from the data bus. The ALU also provides a set of condition codes as a result of the current arithmetic or logic operation. The condition codes, along with other computer status information, are

stored in a register for later use by the programmer or computer control unit.

The program counter and the memory address register are the two main sources of memory word and I/O address select data on the address bus. The program counter contains the address of the next instruction or instruction operand that is to be fetched from main memory, and the memory address register contains instruction address operands which are necessary to fetch the data required for the execution of the current instruction.

A subroutine address stack is provided to allow the return address linkage to be handled easily when exiting a subroutine. The address stack is a last-in, first-out stack that is controlled by a jump-to-subroutine, PUSH, or a return-from-subroutine, POP, instruction from the CCU microinstruction word.

The next microprogram address control (NMAC) circuitry controls the generation of microinstruction addresses. Based on microprogram control, interrupt requests, test conditions and commands from a control panel or other processor, the NMAC determines the address of the next microinstruction to be executed.

For a more detailed description of the above portions of the computer, refer to Advanced Micro Devices' Application Note *A Microprogrammed 16 Bit Computer* by James R.W. Clymer.

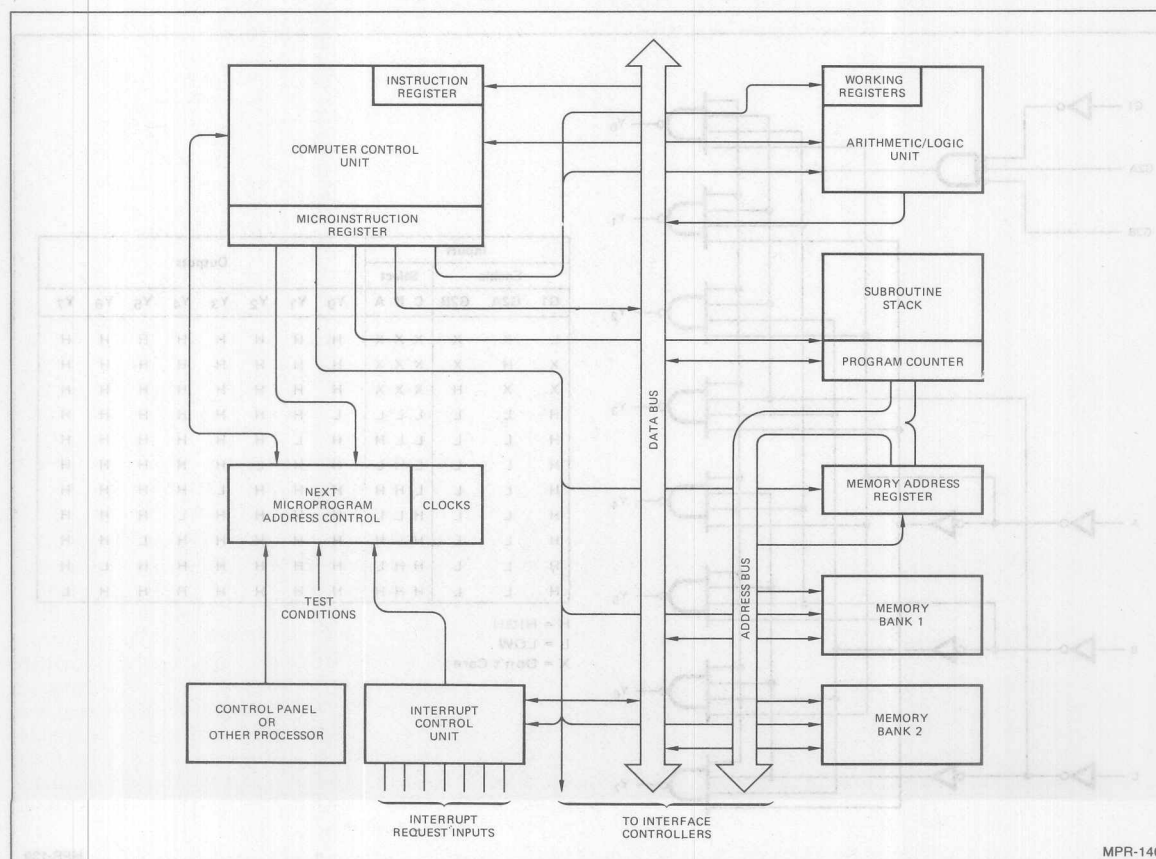


Figure 13. Generalized Computer Architecture.

# Am2914 PRIORITY INTERRUPT ENCODER DETAILED LOGIC DESCRIPTION

## INTRODUCTION

A clear understanding of the Am2914 Priority Interrupt controller's operation facilitates its efficient use. With that idea in mind, a detailed logic description of the Am2914 is presented here. A detailed logic diagram and control signal truth table are shown, and significant aspects of the Am2914 design are described verbally.

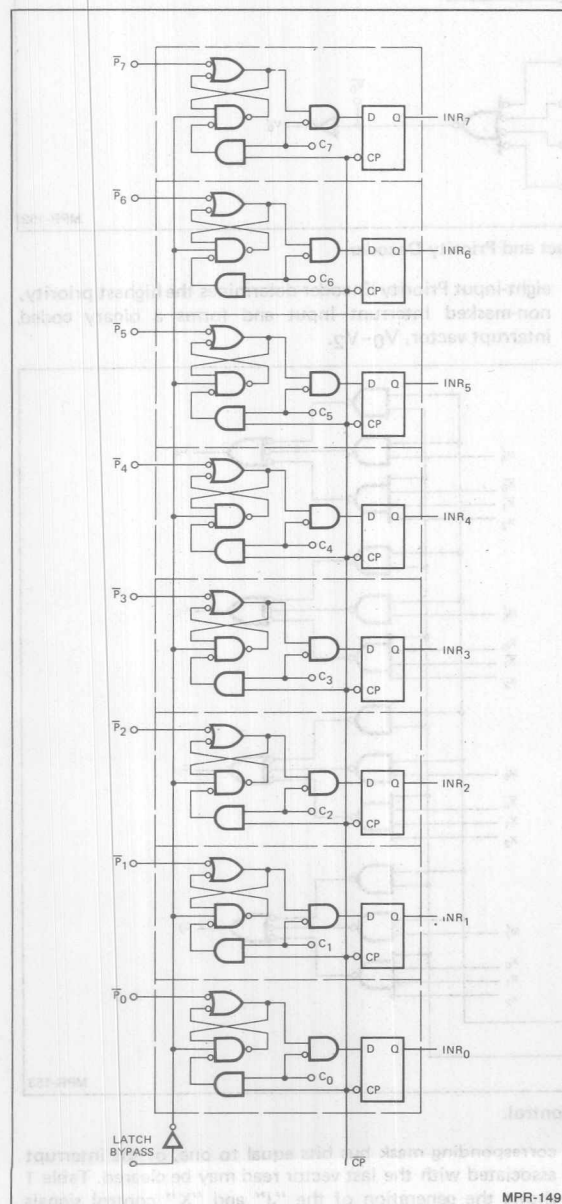


Figure 1. Interrupt Latches and Register.

## LOGIC DIAGRAM DESCRIPTION

The Interrupt Latches and Register are shown in Figure 1. The Interrupt latches are set/reset-type latches. When the Latch Bypass signal is LOW, the latches are enabled and act as negative pulse catchers on the inputs to the Interrupt Register. When the Latch Bypass signal is HIGH, the Interrupt latches are transparent. The Interrupt Register holds the Interrupt Inputs and is an eight-bit, edge-triggered register. It is updated on the LOW-to-HIGH transition of the clock pulse (HIGH-to-LOW transition of the  $\overline{CP}$  signal) as are all of the flip-flops on the chip.

2

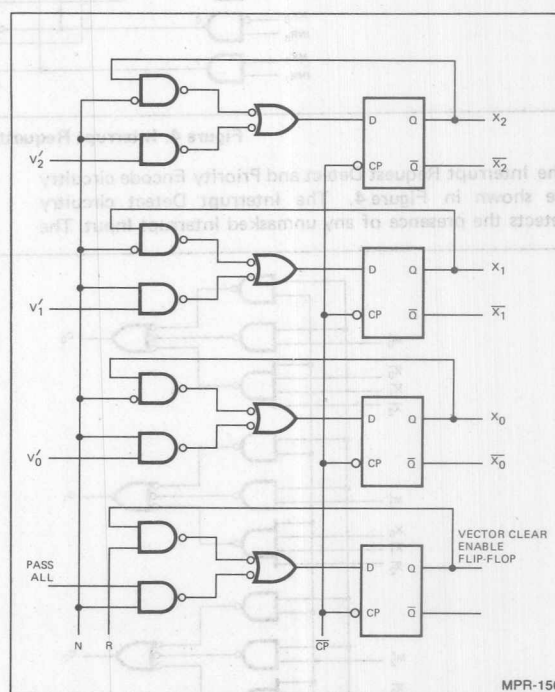


Figure 2. Vector Hold Register

When a Read Vector instruction is executed, the binary coded vector is loaded into the Vector Hold Register of Figure 2. This stored vector can be used later for clearing the interrupt associated with the last vector that was read. The Vector Clear Enable Flip-Flop of Figure 2 is set when a Read Vector instruction is executed and the PASS ALL signal is HIGH. A HIGH PASS ALL signal level indicates that this group is enabled and that an interrupt request in this group was detected and passed priority. The Vector Hold Register and the Vector Clear Enable Flip-Flop are cleared when a Master Clear, Clear All Interrupts, or Clear Interrupt Last Vector Read is executed. Table 1 shows the generation of the "N and R" control signals for each of these operations.

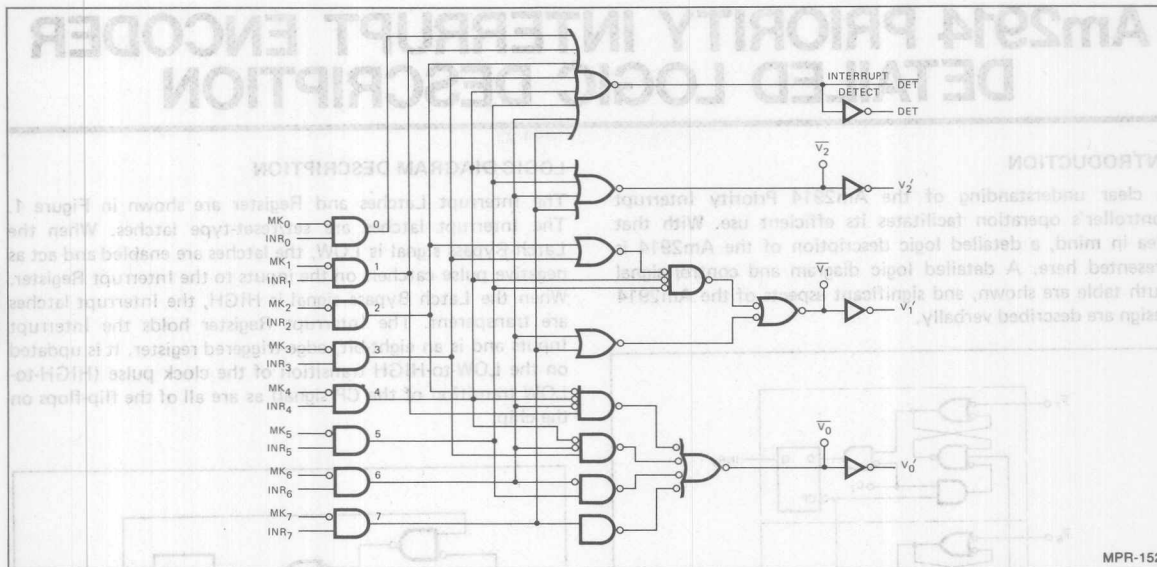


Figure 4. Interrupt Request Detect and Priority Decoder.

The Interrupt Request Detect and Priority Encode circuitry are shown in Figure 4. The Interrupt Detect circuitry detects the presence of any unmasked Interrupt Input. The

eight-input Priority Encoder determines the highest priority, non-masked Interrupt Input and forms a binary coded interrupt vector,  $V_0$ - $V_2$ .

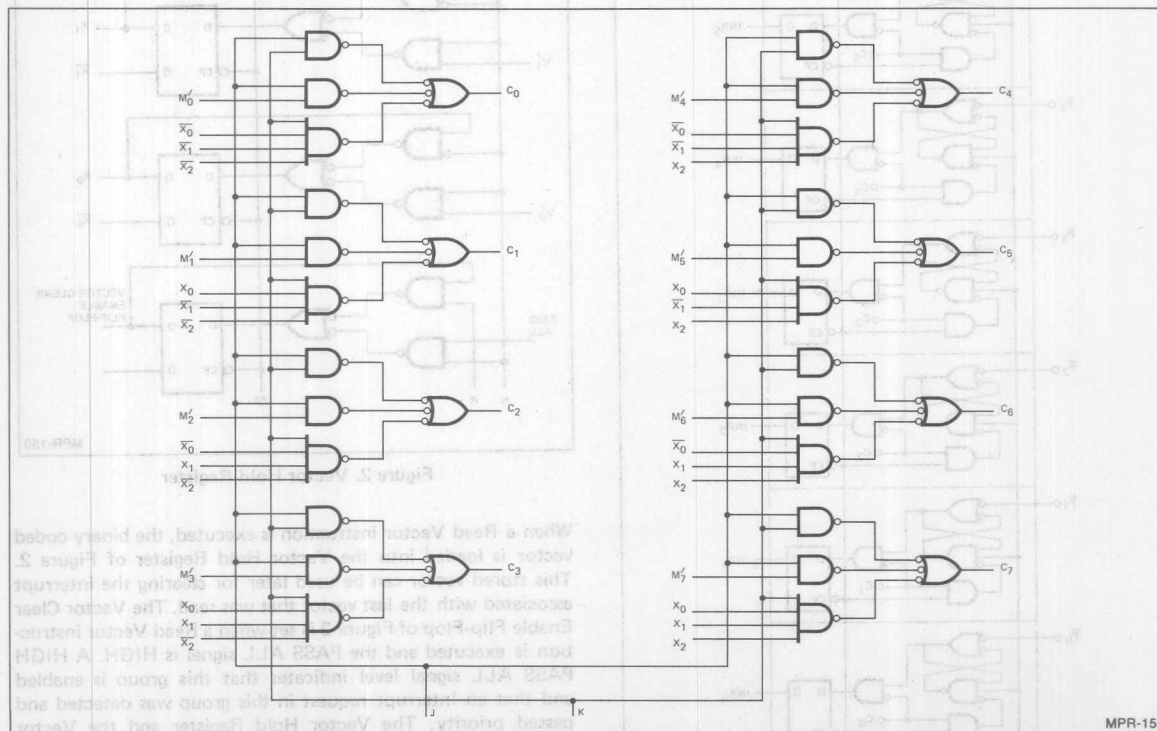


Figure 5. Clear Control.

The Clear Control logic of Figure 5 generates the eight individual clear signals for the eight Interrupt Register bits. Under microinstruction control, all interrupts, interrupts with corresponding mask register bits set, interrupts with

corresponding mask bus bits equal to one, or the interrupt associated with the last vector read may be cleared. Table 1 shows the generation of the "J" and "K" control signals for each of these operations.



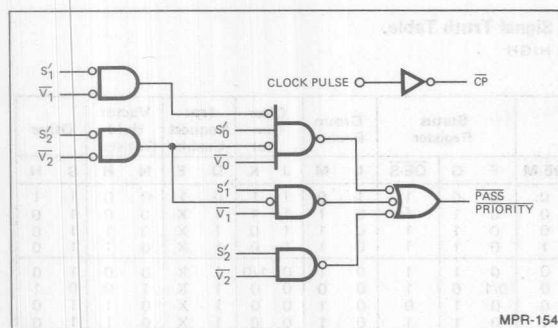


Figure 6. Three-Bit comparator.

The three-bit Comparator of Figure 6 compares the interrupt vector with the contents of the Status Register. A LOW signal level at the PASS PRIORITY output indicates that the interrupt vector is greater than or equal to the contents of the Status Register.

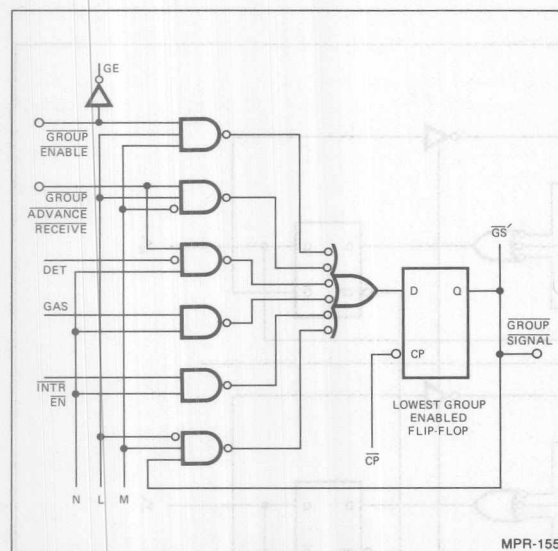


Figure 7. Group Enable Logic.

The Lowest Group Enabled Flip-Flop, Figure 7, is used when a number of Am2914's are cascaded. In a cascaded system, only one Lowest Group Enabled Flip-Flop is LOW at a time. It indicates the group which contains the lowest priority interrupt which will be accepted and is used to form the high order status bits. When a Load Status instruction is executed, the flip-flop is loaded from the GROUP ENABLE input. When a

Master Clear instruction is executed, it is loaded from the GROUP ADVANCE RECEIVE input. The flip-flop is set HIGH when a Read Vector instruction is executed if a Group Advance is not received and no interrupt in this group is detected, if a Group Advance is sent from this group, or if interrupts from this group are disabled. For all other instructions, the flip-flop remains the same. Table 1 shows the generation of the "N", "L" and "M" control signals for these operations.

The Status Register holds the status bits and may be loaded from or read to the "S" bus as shown in Figure 8. Note that when a Load Status instruction is executed, status from the "S" bus is loaded into the Status Register only if the GROUP ENABLE input is LOW; if the GROUP ENABLE input is HIGH, the Status Register is cleared. Also note that during a Read Status instruction, the Status Register outputs are enabled onto the "S" bus only if the Lowest Group Enabled Flip-Flop of this group is LOW. When a Read Vector instruction is executed, the incrementer increases the vector by one and the result is loaded into the Status Register. Thus, the Status Register always points to the lowest level at which an interrupt will be accepted. Table 1 shows the generation of the "F", "G" and "OE-S" control signals for Status Register operations.

The Interrupt Request Logic, shown in Figure 9, generates the RIPPLE DISABLE, PARALLEL DISABLE, INTERRUPT REQUEST, GROUP ADVANCE SEND, and STATUS OVERFLOW output signals. The PARALLEL DISABLE signal is generated when the Lowest Group Enabled signal is LOW or an interrupt request in this group is detected and passes priority. The RIPPLE DISABLE signal is generated when the PARALLEL DISABLE signal is generated and also when the INTERRUPT DISABLE input signal is LOW. The INTERRUPT REQUEST output signal is generated when interrupt requests in this group are enabled and a request is detected and passes priority. The GROUP ADVANCE SEND output signal is generated when a vector of value seven is being read. The Status Overflow Flip-Flop is set LOW when a vector of value seven is read and indicates the Status Register has overflowed. The Interrupt Request Enable Flip-Flop is either set or reset by the Enable Request or Disable Request microinstructions respectively, and is used to enable or disable the INTERRUPT REQUEST output. Table 1 shows the generation of control signals "D", "E", "S" and "H".

Note that the vector outputs are enabled only when a Read Vector is being executed. Also note that when a Read Vector instruction is executed, the vector outputs will be disabled after the execution of the instruction since the Status Register is loaded with V+1, and the INTERRUPT REQUEST will no longer be generated.

The Microinstruction Decode circuitry, Figure 10, decodes the Am2914 microinstructions and generates the required internal control signals. Table 1 shows the truth table for these functions and Figure 11 shows the function tables.

|         | Microinstruction |       |       |       |       | Function                | Mask Register |   |   |      | Status Register |   |                   | Group Enable |   | Clear Control |     | Irpt Request Enable |   | Vector Hold Register |   | Other |   |   |
|---------|------------------|-------|-------|-------|-------|-------------------------|---------------|---|---|------|-----------------|---|-------------------|--------------|---|---------------|-----|---------------------|---|----------------------|---|-------|---|---|
| Decimal | $\overline{I_E}$ | $I_3$ | $I_2$ | $I_1$ | $I_0$ | Description             | A             | B | C | OE-M | F               | G | $\overline{OE-S}$ | L            | M | J             | K   | D                   | E | N                    | R | S     | H |   |
| 0       | 0                | 0     | 0     | 0     | 0     | Master Clear            | 0             | 0 | 1 | 0    | 0               | 0 | 1                 | 1            | 0 | 1             | 1   | 0                   | 1 | 0                    | 0 | 0     | 1 | 1 |
| 1       | 0                | 0     | 0     | 0     | 1     | Clear All Interrupts    | 1             | 0 | 1 | 0    | 0               | 1 | 1                 | 0            | 1 | 1             | 1   | 1                   | X | 0                    | 0 | 1     | 0 |   |
| 2       | 0                | 0     | 0     | 1     | 0     | Clear Intr Via M Bus    | 1             | 0 | 1 | 0    | 0               | 1 | 1                 | 0            | 1 | 1             | 0   | 1                   | X | 0                    | 1 | 1     | 0 |   |
| 3       | 0                | 0     | 0     | 1     | 1     | Clear Intr Via M Reg    | 1             | 0 | 1 | 1    | 0               | 1 | 1                 | 0            | 1 | 1             | 0   | 1                   | X | 0                    | 1 | 1     | 0 |   |
| 4       | 0                | 0     | 1     | 0     | 0     | Clear Intr, Last Vector | 1             | 0 | 1 | 0    | 0               | 1 | 1                 | 0            | 1 | 0             | 1/0 | 1                   | X | 0                    | 0 | 1     | 0 |   |
| 5       | 0                | 0     | 1     | 0     | 1     | Read Vector             | 1             | 0 | 1 | 0    | 0/1             | 0 | 1                 | 0            | 0 | 0             | 0   | 1                   | X | 1                    | 0 | 0     | 1 |   |
| 6       | 0                | 0     | 1     | 1     | 0     | Read Status Reg         | 1             | 0 | 1 | 0    | 0               | 1 | 0                 | 0            | 1 | 0             | 0   | 1                   | X | 0                    | 1 | 1     | 0 |   |
| 7       | 0                | 0     | 1     | 1     | 1     | Read Mask Reg           | 1             | 0 | 1 | 1    | 0               | 1 | 1                 | 0            | 1 | 0             | 0   | 1                   | X | 0                    | 1 | 1     | 0 |   |
| 8       | 0                | 1     | 0     | 0     | 0     | Set Mask Reg            | 0             | 0 | 0 | 0    | 0               | 1 | 1                 | 0            | 1 | 0             | 0   | 1                   | X | 0                    | 1 | 1     | 0 |   |
| 9       | 0                | 1     | 0     | 0     | 1     | Load Status Reg         | 1             | 0 | 1 | 0    | 1               | 1 | 1                 | 1            | 1 | 0             | 0   | 1                   | X | 0                    | 1 | 1     | 1 |   |
| 10      | 0                | 1     | 0     | 1     | 0     | Bit Clear Mask Reg      | 0             | 1 | 0 | 0    | 0               | 1 | 1                 | 0            | 1 | 0             | 0   | 1                   | X | 0                    | 1 | 1     | 0 |   |
| 11      | 0                | 1     | 0     | 1     | 1     | Bit Set Mask Reg        | 1             | 1 | 1 | 0    | 0               | 1 | 1                 | 0            | 1 | 0             | 0   | 1                   | X | 0                    | 1 | 1     | 0 |   |
| 12      | 0                | 1     | 1     | 0     | 0     | Clear Mask Reg          | 0             | 0 | 1 | 0    | 0               | 1 | 1                 | 0            | 1 | 0             | 0   | 1                   | X | 0                    | 1 | 1     | 0 |   |
| 13      | 0                | 1     | 1     | 0     | 1     | Disable Request         | 1             | 0 | 1 | 0    | 0               | 1 | 1                 | 0            | 1 | 0             | 0   | 0                   | 0 | 0                    | 1 | 1     | 0 |   |
| 14      | 0                | 1     | 1     | 1     | 0     | Load Mask Reg           | 0             | 1 | 1 | 0    | 0               | 1 | 1                 | 0            | 1 | 0             | 0   | 1                   | X | 0                    | 1 | 1     | 0 |   |
| 15      | 0                | 1     | 1     | 1     | 1     | Enable Request          | 1             | 0 | 1 | 0    | 0               | 1 | 1                 | 0            | 1 | 0             | 0   | 0                   | 1 | 0                    | 1 | 1     | 0 |   |
| X       | 1                | X     | X     | X     | X     | Instruction Disable     | 1             | 0 | 1 | 0    | 0               | 1 | 1                 | 0            | 1 | 0             | 0   | 1                   | X | 0                    | 1 | 1     | 0 |   |

Notes: 1. Control line "F" during "READ VECTOR" instruction is 0 when "PASS ALL" is LOW and 1 when "PASS ALL" is HIGH.  
 2. Control line "K" during "Clear Intr, Last Vector" instruction is 0 when "Vector Clear Enable" is LOW and 1 when "Vector Clear Enable" is HIGH.

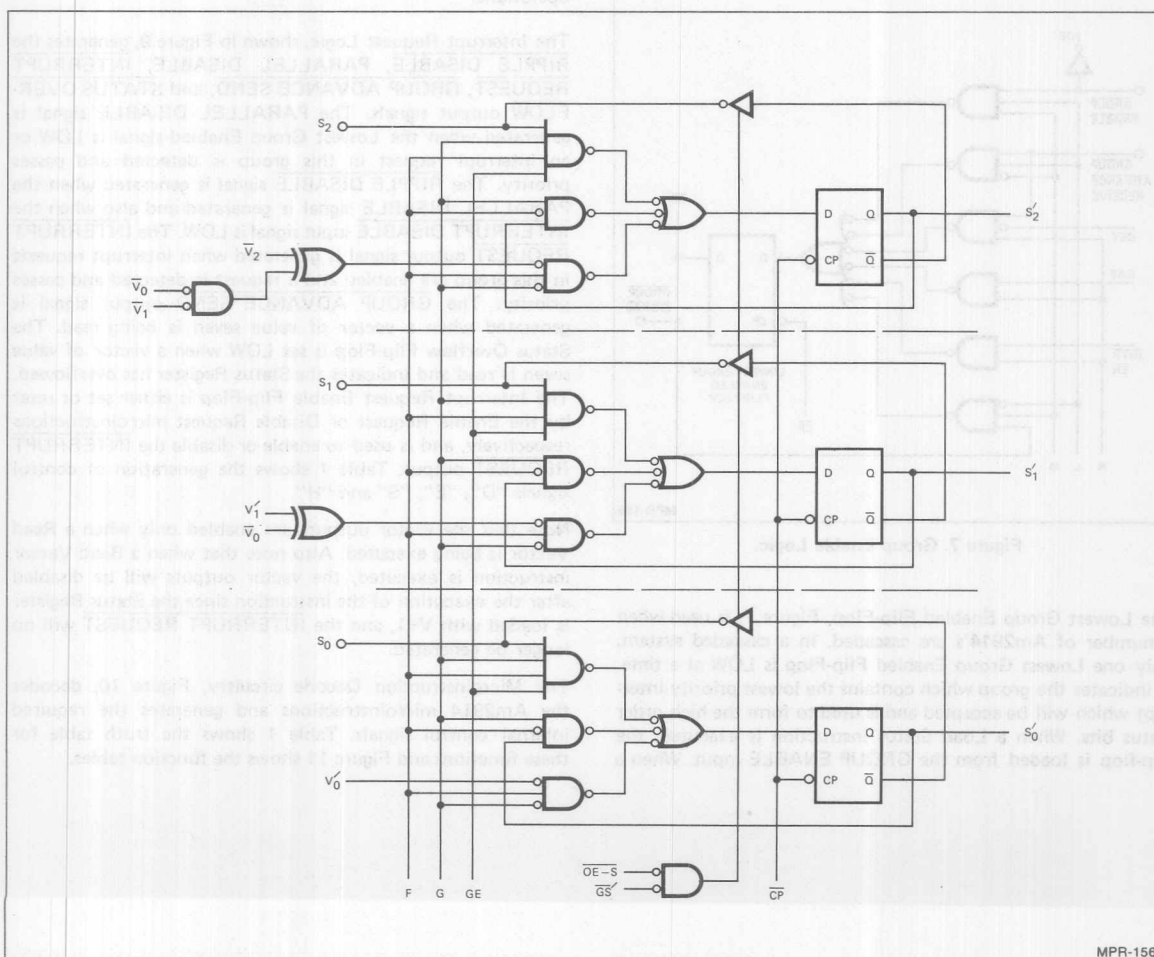


Figure 8. Incrementer and Status Register.

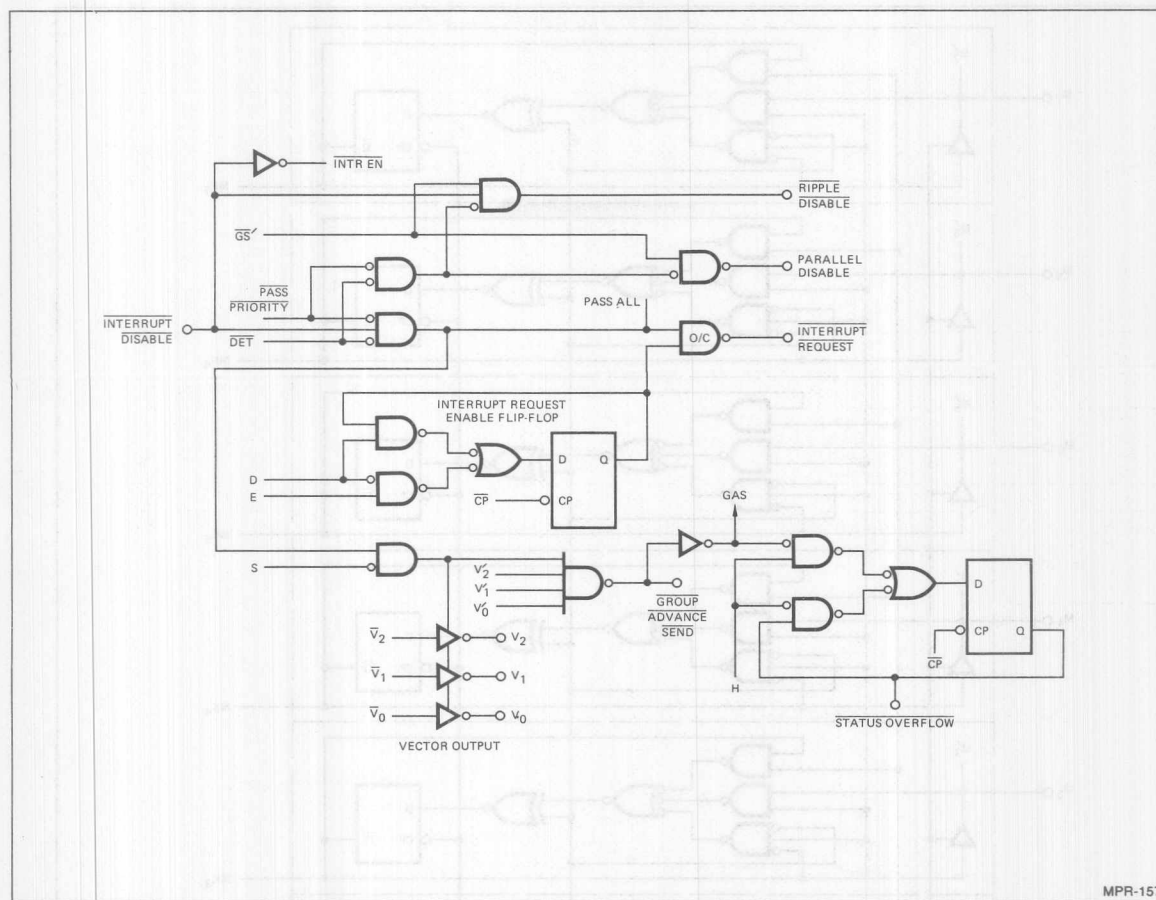


Figure 9. Interrupt Request Logic.

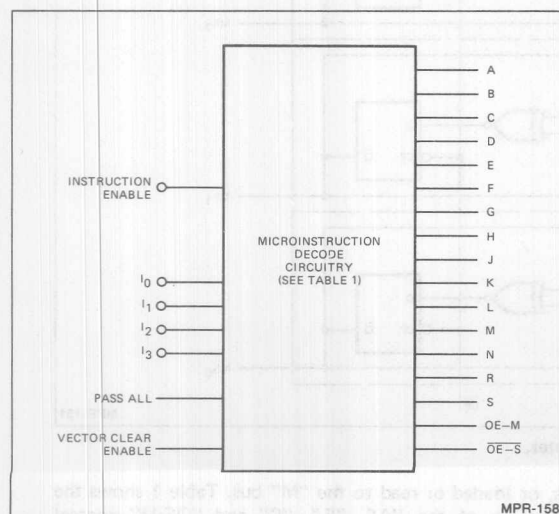


Figure 10.

| MASK REGISTER |   |   |           |
|---------------|---|---|-----------|
| A             | B | C | FUNCTION  |
| 0             | 0 | 0 | SET       |
| 0             | 0 | 1 | CLEAR     |
| 0             | 1 | 0 | BIT CLEAR |
| 0             | 1 | 1 | LOAD      |
| 1             | 0 | 1 | HOLD      |
| 1             | 1 | 1 | BIT SET   |

| CLEAR CONTROL |                      |
|---------------|----------------------|
| J             | K      FUNCTION      |
| 0             | 0 NO CLEAR           |
| 0             | 1 CLEAR IRPT, VECTOR |
| 1             | 0 CLEAR IRPTS VIA M  |
| 1             | 1 CLEAR ALL IRPTS    |

| VECTOR HOLD REGISTER |          |
|----------------------|----------|
| N                    | FUNCTION |
| 0                    | HOLD     |
| 1                    | LOAD     |

| LOWEST GROUP ENABLED FLIP-FLOP |                                  |
|--------------------------------|----------------------------------|
| L                              | M      FUNCTION                  |
| 0                              | 0 UPDATE                         |
| 0                              | 1 HOLD                           |
| 1                              | 0 LOAD VIA GROUP ADVANCE RECEIVE |
| 1                              | 1 LOAD VIA GROUP ENABLE          |

 | STATUS REGISTER |   |                  | |-----------------|---|------------------| | F               | G | FUNCTION         | | 0               | 0 | CLEAR            | | 0               | 1 | HOLD             | | 1               | 0 | LOAD VECTOR + 1  | | 1               | 1 | LOAD VIA "S" BUS |     | INTERRUPT REQUEST ENABLE FLIP-FLOP |                 | |------------------------------------|-----------------| | D                                  | E      FUNCTION | | 0                                  | 0 DISABLE IRPTS | | 0                                  | 1 ENABLE IRPTS  | | 1                                  | X HOLD          |     | VECTOR CLEAR ENABLE FLIP-FLOP |                 | |-------------------------------|-----------------| | N                             | R      FUNCTION | | 0                             | 0 CLEAR         | | 0                             | 1 HOLD          | | 1                             | 0 LOAD          |     | STATUS OVERFLOW FLIP-FLOP |          | |---------------------------|----------| | H                         | FUNCTION | | 0                         | HOLD     | | 1                         | LOAD     | |

Figure 11. Control Function Tables.

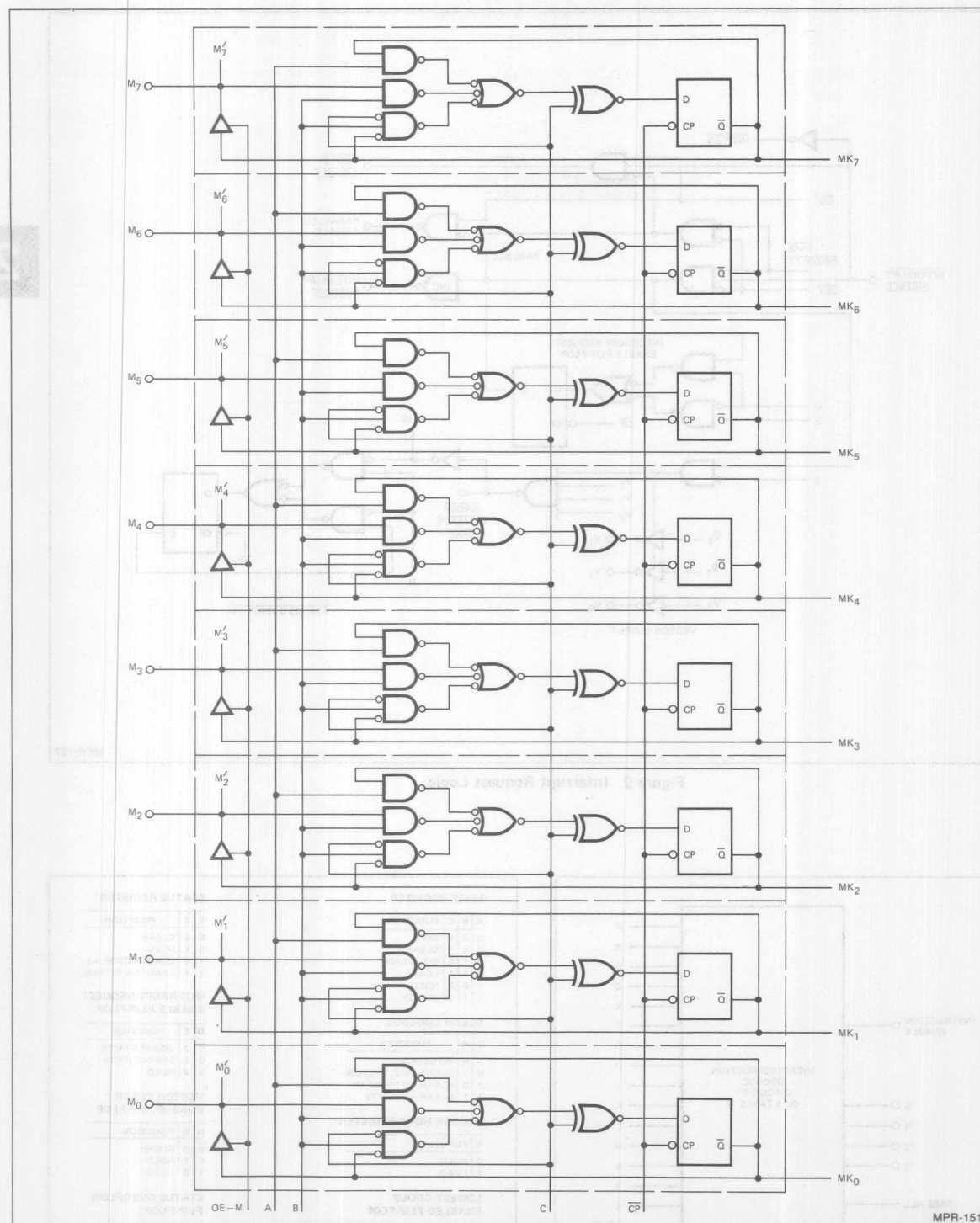


Figure 3. Mask Register.

The Mask Register shown in Figure 3 holds the eight mask bits associated with the eight interrupt levels. The register may be set or cleared, bit set or bit cleared from the "M"

bus, or loaded or read to the "M" bus. Table 1 shows the generation of the "A", "B", "C" and "OE-M" control signals for each of these operations.



# Am2915A

## Quad Three-State Bus Transceiver With Interface Logic

### Distinctive Characteristics

- Quad high-speed LSI bus-transceiver
- Three-state bus driver
- Two-port input to D-type register on driver
- Bus driver output can sink 48mA at 0.5V max.
- Receiver has output latch for pipeline operation

- Three-state receiver outputs sink 12mA
- Advanced low-power Schottky processing
- 100% reliability assurance testing in compliance with MIL-STD-883
- 3.5V minimum output high voltage for direct interface to MOS microprocessors

### FUNCTIONAL DESCRIPTION

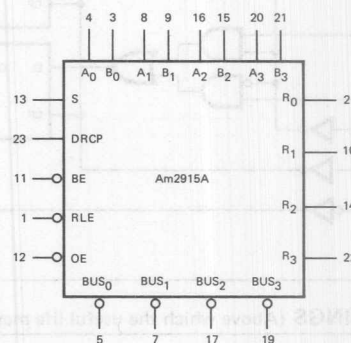
The Am2915A is a high-performance, low-power Schottky bus transceiver intended for bipolar or MOS microprocessor system applications. The device consists of four D-type edge-triggered flip-flops with a built-in two-input multiplexer on each. The flip-flop outputs are connected to four three-state bus drivers. Each bus driver is internally connected to the input of a receiver. The four receiver outputs drive four D-type latches that feature three-state outputs.

This LSI bus transceiver is fabricated using advanced low-power Schottky processing. All inputs (except the BUS inputs) are one LS unit load. The three-state bus output can sink up to 48mA at 0.5V maximum. The bus enable input (BE) is used to force the driver outputs to the high-impedance state. When  $\overline{BE}$  is HIGH, the driver is disabled. The  $V_{OH}$  and  $V_{OL}$  of the bus driver are selected for compatibility with standard and Low-Power Schottky inputs.

The input register consists of four D-type flip-flops with a buffered common clock and a two-input multiplexer at the input of each flip-flop. A common select input (S) controls the four multiplexers. When S is LOW, the  $A_i$  data is stored in the register and when S is HIGH, the  $B_i$  data is stored. The buffered common clock (DRCP) enters the data into this driver register on the LOW-to-HIGH transition.

Data from the A or B inputs is inverted at the BUS output. Likewise, data at the BUS input is inverted at the receiver output. Thus, data is non-inverted from driver input to receiver output. The four receivers each feature a built-in D-type latch that is controlled from the buffered receiver latch enable (RLE) input. When the RLE input is LOW, the latch is open and the receiver outputs will follow the bus inputs (BUS data inverted and OE LOW). When the RLE input is HIGH, the latch will close and retain the present data regardless of the bus input. The four latches have three-state outputs and are controlled by a buffered common three-state control (OE) input. When OE is HIGH, the receiver outputs are in the high-impedance state.

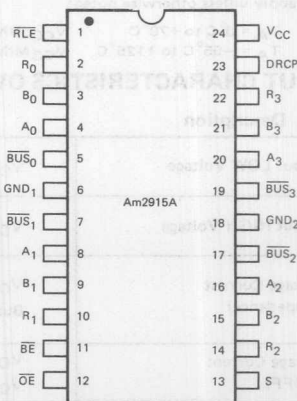
### LOGIC SYMBOL



$V_{CC}$  = Pin 24  
 $GND_1$  = Pin 6  
 $GND_2$  = Pin 18

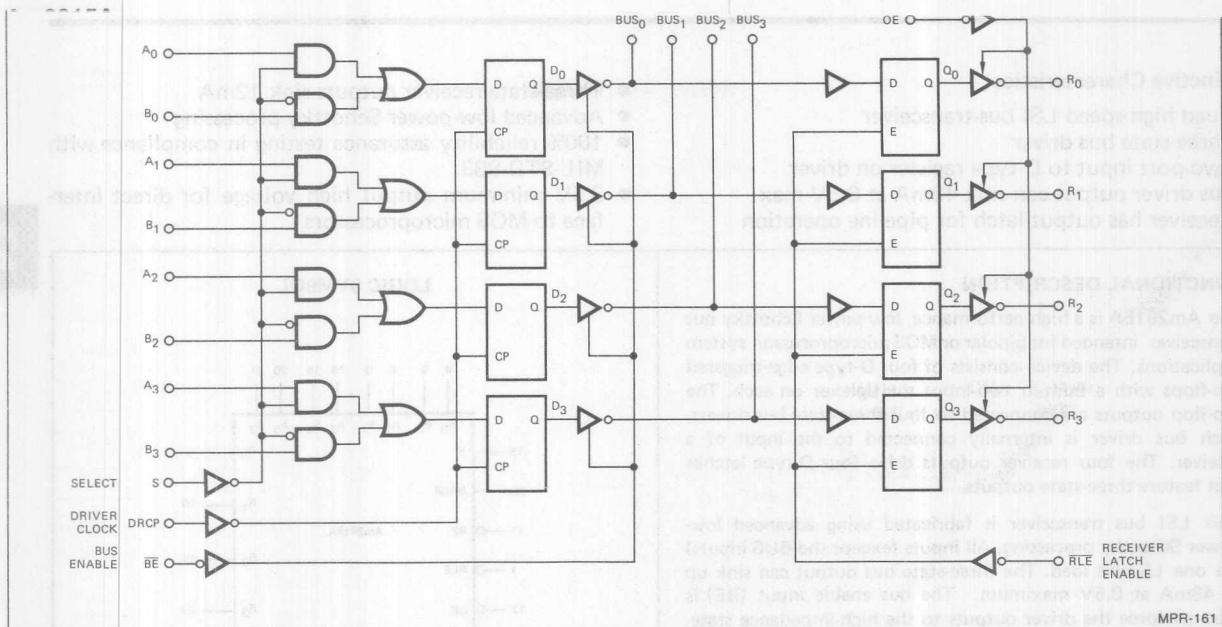
MPR-159

### CONNECTION DIAGRAM Top View



Note: Pin 1 is marked for orientation.

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MPR-161

## MAXIMUM RATINGS (Above which the useful life may be impaired)

|   |                                |
|---|--------------------------------|
| Storage Temperature                                 | -65°C to +150°C                |
| Temperature (Ambient) Under Bias                    | -55°C to +125°C                |
| Supply Voltage to Ground Potential                  | -0.5V to +7V                   |
| DC Voltage Applied to Outputs for HIGH Output State | -0.5V to +V <sub>CC</sub> max. |
| DC Input Voltage                                    | -0.5V to +7V                   |
| DC Output Current, Into Outputs (Except Bus)        | 30mA                           |
| DC Output Current, Into Bus                         | 100mA                          |
| DC Input Current                                    | -30mA to +5.0mA                |

## ELECTRICAL CHARACTERISTICS

The following conditions apply unless otherwise noted:

|                   |                                  |                               |                               |
|-------------------|----------------------------------|-------------------------------|-------------------------------|
| Am2915AXC (COM'L) | T <sub>A</sub> = 0°C to +70°C    | V <sub>CC</sub> MIN. = 4.75 V | V <sub>CC</sub> MAX. = 5.25 V |
| Am2915AXM (MIL)   | T <sub>A</sub> = -55°C to +125°C | V <sub>CC</sub> MIN. = 4.50 V | V <sub>CC</sub> MAX. = 5.50 V |

## BUS INPUT/OUTPUT CHARACTERISTICS OVER OPERATING TEMPERATURE RANGE

| Parameters       | Description                          | Test Conditions (Note 1)                        | Min.                           | Typ. | Max. | Units |
|------------------|--------------------------------------|---|--------------------------------|------|------|-------|
| V <sub>OL</sub>  | Bus Output LOW Voltage               | V <sub>CC</sub> = MIN.                          | I <sub>OL</sub> = 24mA         |      | 0.4  | Volts |
|                  |                                      |   | I <sub>OL</sub> = 48mA         |      | 0.5  |       |
| V <sub>OH</sub>  | Bus Output HIGH Voltage              | V <sub>CC</sub> = MIN.                          | COM'L, I <sub>OH</sub> = -20mA | 2.4  |      | Volts |
|                  |                                      |   | MIL, I <sub>OH</sub> = -15mA   |      |      |       |
| I <sub>O</sub>   | Bus Leakage Current (High Impedance) | V <sub>CC</sub> = MAX.<br>Bus enable = 2.4 V    | V <sub>O</sub> = 0.4 V         |      | -200 | μA    |
|                  |                                      |   | V <sub>O</sub> = 2.4 V         |      | 50   |       |
|                  |                                      |   | V <sub>O</sub> = 4.5 V         |      | 100  |       |
| I <sub>OFF</sub> | Bus Leakage Current (Power OFF)      | V <sub>O</sub> = 4.5 V<br>V <sub>CC</sub> = 0 V |                                |      | 100  | μA    |
| V <sub>IH</sub>  | Receiver Input HIGH Threshold        | Bus enable = 2.4 V                              | 2.0                            |      |      | Volts |
| V <sub>IL</sub>  | Receiver Input LOW Threshold         | Bus enable = 2.4 V                              | COM'L                          |      | 0.8  | Volts |
|                  |                                      |   | MIL                            |      | 0.7  |       |
| I <sub>SC</sub>  | Bus Output Short Circuit Current     | V <sub>CC</sub> = MAX.<br>V <sub>O</sub> = 0 V  | -50                            | -120 | -225 | mA    |

## ELECTRICAL CHARACTERISTICS

The following conditions apply unless otherwise noted:

Am2915AXC (COM'L)  $T_A = 0^\circ\text{C to } +70^\circ\text{C}$   $V_{CC\text{ MIN.}} = 4.75\text{ V}$   $V_{CC\text{ MAX.}} = 5.25\text{ V}$   
 Am2915AXM (MIL)  $T_A = -55^\circ\text{C to } +125^\circ\text{C}$   $V_{CC\text{ MIN.}} = 4.50\text{ V}$   $V_{CC\text{ MAX.}} = 5.50\text{ V}$

## DC CHARACTERISTICS OVER OPERATING TEMPERATURE RANGE

| Parameters | Description                                    | Test Conditions (Note 1)                                       |                                  | Min. | Typ.<br>(Note 2) | Max.  | Units         |
|------------|--|--|----------------------------------|------|------------------|-------|---------------|
| $V_{OH}$   | Receiver Output HIGH Voltage                   | $V_{CC} = \text{MIN.}$   | MIL: $I_{OH} = -1.0\text{ mA}$   | 2.4  | 3.4              |       | Volts         |
|            |  | $V_{IN} = V_{IL} \text{ or } V_{IH}$                           | COM'L: $I_{OH} = -2.6\text{ mA}$ | 2.4  | 3.4              |       |               |
|            |  | $V_{CC} = 5.0\text{ V}, I_{OH} = -100\text{ }\mu\text{A}$      |                                  | 3.5  |                  |       |               |
| $V_{OL}$   | Output LOW Voltage<br>(Except Bus)             | $V_{CC} = \text{MIN.}$<br>$V_{IN} = V_{IL} \text{ or } V_{IH}$ | $I_{OL} = 4.0\text{ mA}$         |      | 0.27             | 0.4   | Volts         |
|            |  |  | $I_{OL} = 8.0\text{ mA}$         |      | 0.32             | 0.45  |               |
|            |  |  | $I_{OL} = 12\text{ mA}$          |      | 0.37             | 0.5   |               |
| $V_{IH}$   | Input HIGH Level<br>(Except Bus)               | Guaranteed input logical HIGH for all inputs                   |                                  | 2.0  |                  |       | Volts         |
| $V_{IL}$   | Input LOW Level<br>(Except Bus)                | Guaranteed input logical LOW for all inputs                    | MIL                              |      |                  | 0.7   | Volts         |
|            |  |  | COM'L                            |      |                  | 0.8   |               |
| $V_I$      | Input Clamp Voltage (Except Bus)               | $V_{CC} = \text{MIN.}, I_{IN} = -18\text{ mA}$                 |                                  |      |                  | -1.2  | Volts         |
| $I_{IL}$   | Input LOW Current (Except Bus)                 | $V_{CC} = \text{MAX.}, V_{IN} = 0.4\text{ V}$                  | BE, RLE                          |      |                  | -0.72 | mA            |
|            |  |  | All other inputs                 |      |                  | -0.36 |               |
| $I_{IH}$   | Input HIGH Current (Except Bus)                | $V_{CC} = \text{MAX.}, V_{IN} = 2.7\text{ V}$                  |                                  |      |                  | 20    | $\mu\text{A}$ |
| $I_I$      | Input HIGH Current (Except Bus)                | $V_{CC} = \text{MAX.}, V_{IN} = 7.0\text{ V}$                  |                                  |      |                  | 100   | $\mu\text{A}$ |
| $I_{SC}$   | Output Short Circuit Current<br>(Except Bus)   | $V_{CC} = \text{MAX.}$   |                                  | -30  |                  | -130  | mA            |
| $I_{CC}$   | Power Supply Current                           | $V_{CC} = \text{MAX.}$   |                                  |      | 63               | 95    | mA            |
| $I_O$      | Off-State Output Current<br>(Receiver Outputs) | $V_{CC} = \text{MAX.}$   | $V_O = 2.4\text{ V}$             |      |                  | 50    | $\mu\text{A}$ |
|            |  |  | $V_O = 0.4\text{ V}$             |      |                  | -50   |               |

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## SWITCHING CHARACTERISTICS OVER OPERATING TEMPERATURE RANGE

|                                   |  |  | Am2915AXM |          |      | Am2915AXC |          |      |       |
|-----------------------------------|--|--|-----------|----------|------|-----------|----------|------|-------|
| Parameters                        | Description                              | Test Conditions  | Typ.      |          |      | Typ.      |          |      | Units |
|                                   |  |  | Min.      | (Note 2) | Max. | Min.      | (Note 2) | Max. |       |
| t <sub>PHL</sub>                  | Driver Clock (DRCP) to Bus               | C <sub>L</sub> (BUS) = 50pF<br>R <sub>L</sub> (BUS) = 130Ω |           | 21       | 36   |           | 21       | 32   | ns    |
| t <sub>PLH</sub>                  |  |  |           | 21       | 36   |           | 21       | 32   |       |
| t <sub>ZH</sub> , t <sub>ZL</sub> | Bus Enable ( $\overline{BE}$ ) to Bus    |  |           | 13       | 26   |           | 13       | 23   | ns    |
| t <sub>HZ</sub> , t <sub>LZ</sub> |  |  |           | 13       | 21   |           | 13       | 18   |       |
| t <sub>s</sub>                    | Data Inputs (A or B)                     | C <sub>L</sub> = 15pF<br>R <sub>L</sub> = 2.0kΩ            | 15        |          |      | 12        |          |      | ns    |
| t <sub>h</sub>                    |  |  | 8.0       |          |      | 6.0       |          |      |       |
| t <sub>s</sub>                    | Select Input (S)                         |  | 28        |          |      | 25        |          | ns   |       |
| t <sub>h</sub>                    |  |  | 8.0       |          |      | 6.0       |          |      |       |
| t <sub>PW</sub>                   | Driver Clock (DRCP) Pulse Width (HIGH)   |  | 20        |          |      | 17        |          | ns   |       |
| t <sub>PLH</sub>                  | Bus to Receiver Output (Latch Enable)    |  | 18        | 33       |      | 18        | 30       | ns   |       |
| t <sub>PHL</sub>                  |  |  | 18        | 30       |      | 18        | 27       |      |       |
| t <sub>PLH</sub>                  | Latch Enable to Receiver Output          |  | 21        | 33       |      | 21        | 30       | ns   |       |
| t <sub>PHL</sub>                  |  |  | 21        | 30       |      | 21        | 27       |      |       |
| t <sub>s</sub>                    | Bus to Latch Enable ( $\overline{RLE}$ ) |  | 15        |          |      | 13        |          | ns   |       |
| t <sub>h</sub>                    |  | 6.0  |           |          | 4.0  |           |          |      |       |
| t <sub>ZH</sub> , t <sub>ZL</sub> | Output Control to Receiver Output        | C <sub>L</sub> = 5pF, R <sub>L</sub> = 2.0kΩ               | 14        | 26       |      | 14        | 23       | ns   |       |
| t <sub>HZ</sub> , t <sub>LZ</sub> |  |  | 14        | 26       |      | 14        | 23       |      |       |

Notes: 1. For conditions shown as MIN. or MAX., use the appropriate value specified under Electrical Characteristics for the applicable device type.

2. Typical limits are at  $V_{CC} = 5.0\text{ V}$ ,  $25^\circ\text{C}$  ambient and maximum loading.

3. Not more than one output should be shorted at a time. Duration of the short circuit test should not exceed one second.

## FUNCTIONAL TABLE

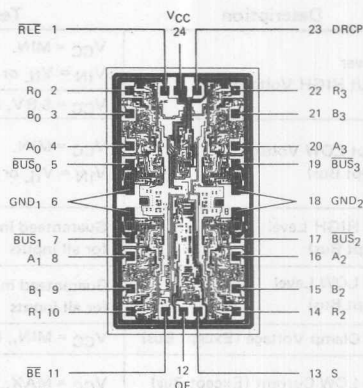
| INPUTS |                |                |      |    |     | INTERNAL TO DEVICE |                | BUS            | OUTPUT           | FUNCTION |  |
|--------|----------------|----------------|------|----|-----|--------------------|----------------|----------------|------------------|----------|--|
| S      | A <sub>i</sub> | B <sub>i</sub> | DRCP | BE | RLE | OE                 | D <sub>i</sub> | Q <sub>i</sub> | BUS <sub>i</sub> |          | R <sub>i</sub>                                       |
| X      | X              | X              | X    | H  | X   | X                  | X              | X              | X                | X        | Driver output disable                                |
| X      | X              | X              | X    | X  | X   | H                  | X              | X              | Z                | Z        | Receiver output disable                              |
| X      | X              | X              | X    | H  | L   | L                  | X              | L              | L                | H        | Driver output disable and receive data via Bus input |
| X      | X              | X              | X    | H  | L   | L                  | X              | H              | H                | L        |  |
| X      | X              | X              | X    | X  | H   | X                  | X              | NC             | X                | X        | Latch received data                                  |
| L      | L              | X              | ↑    | X  | X   | X                  | L              | X              | X                | X        | Load driver register                                 |
| L      | H              | X              | ↑    | X  | X   | X                  | H              | X              | X                | X        |  |
| H      | X              | L              | ↑    | X  | X   | X                  | L              | X              | X                | X        |  |
| H      | X              | H              | ↑    | X  | X   | X                  | H              | X              | X                | X        |  |
| X      | X              | X              | L    | X  | X   | X                  | NC             | X              | X                | X        | No driver clock restrictions                         |
| X      | X              | X              | H    | X  | X   | X                  | NC             | X              | X                | X        |  |
| X      | X              | X              | X    | L  | X   | X                  | L              | X              | H                | X        | Drive Bus  |
| X      | X              | X              | X    | L  | X   | X                  | H              | X              | L                | X        |  |

H = HIGH  
L = LOW

Z = HIGH Impedance  
NC = No change

X = Don't care  
↑ = LOW to HIGH transition  
I = 0, 1, 2, 3

## Metallization and Pad Layout



DIE SIZE .074" X .130"

## DEFINITION OF FUNCTIONAL TERMS

A<sub>0</sub>, A<sub>1</sub>, A<sub>2</sub>, A<sub>3</sub> The "A" word data input into the two input multiplexer of the driver register.

B<sub>0</sub>, B<sub>1</sub>, B<sub>2</sub>, B<sub>3</sub> The "B" word data input into the two input multiplexers of the driver register.

S Select. When the select input is LOW, the A data word is applied to the driver register. When the select input is HIGH, the B word is applied to the driver register.

DRCP Driver Clock Pulse. Clock pulse for the driver register.

BE Bus Enable. When the Bus Enable is HIGH, the four drivers are in the high impedance state.

BUS<sub>0</sub>, BUS<sub>1</sub>  
BUS<sub>2</sub>, BUS<sub>3</sub> The four driver outputs and receiver inputs (data is inverted).

R<sub>0</sub>, R<sub>1</sub>, R<sub>2</sub>, R<sub>3</sub> The four receiver outputs. Data from the bus is inverted while data from the A or B inputs is non-inverted.

RLE Receiver Latch Enable. When RLE is LOW, data on the BUS inputs is passed through the receiver latches. When RLE is HIGH, the receiver latches are closed and will retain the data independent of all other inputs.

OE Output Enable. When the OE input is HIGH, the four three state receiver outputs are in the high-impedance state.

## ORDERING INFORMATION

Order the part number according to the table below to obtain the desired package, temperature range, and screening level.

| Order Number | Package Type<br>(Note 1) | Operating Range<br>(Note 2) | Screening Level<br>(Note 3)                          |
|--------------|--------------------------|-----------------------------|--|
| AM2915APC    | P-24                     | C                           | C-1  |
| AM2915ADC    | D-24                     | C                           | C-1  |
| AM2915ADC-B  | D-24                     | C                           | B-1  |
| AM2915ADM    | D-24                     | M                           | C-3  |
| AM2915ADM-B  | D-24                     | M                           | B-3  |
| AM2915AFM    | F-24-1                   | M                           | C-3  |
| AM2915AFM-B  | F-24-1                   | M                           | B-3  |
| AM2915AXC    | Dice                     | C                           | Visual inspection<br>to MIL-STD-883<br>Method 2010B. |
| AM2915AXM    | Dice                     | M                           |  |

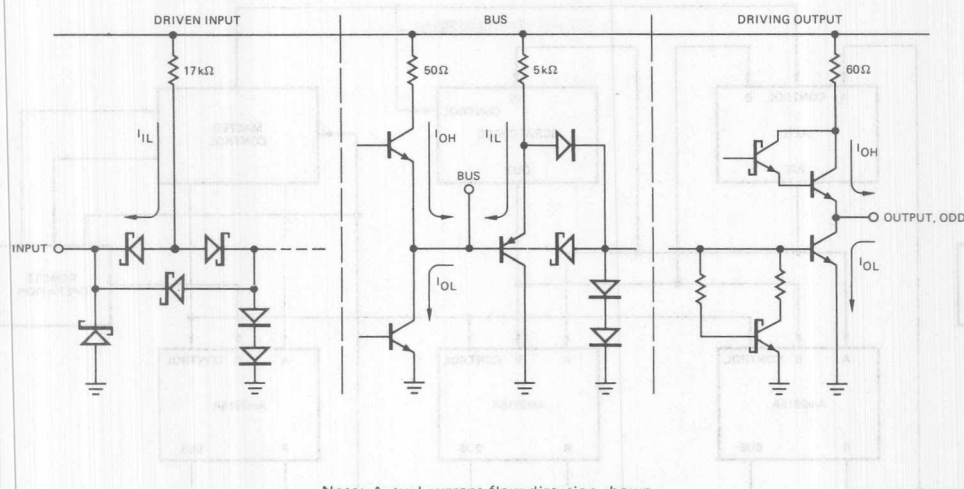
Notes: 1. P = Molded DIP, D = Hermetic DIP, F = Flat Pak. Number following letter is number of leads. See Appendix B for detailed outline.

Where Appendix B contains several dash numbers, any of the variations of the package may be used unless otherwise specified.

2. C = 0°C to +70°C, V<sub>CC</sub> = 4.75V to 5.25V, M = -55°C to +125°C, V<sub>CC</sub> = 4.50V to 5.50V.

3. See Appendix A for details of screening. Levels C-1 and C-3 conform to MIL-STD-883, Class C. Level B-3 conforms to MIL-STD-883, Class B.

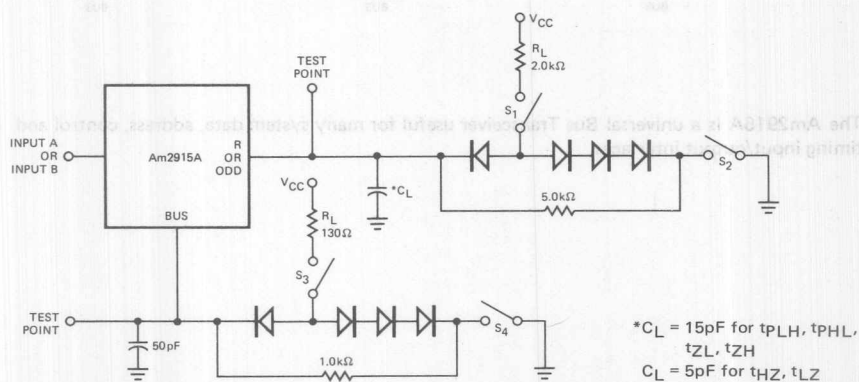


INPUT/OUTPUT CURRENT  
INTERFACE CONDITIONS

Note: Actual current flow direction shown.

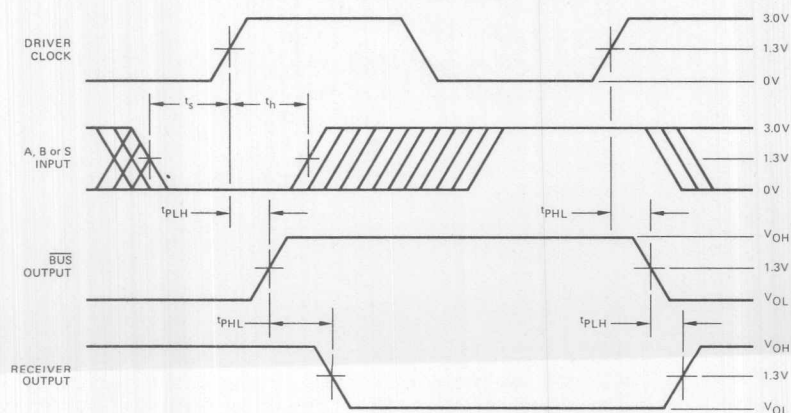
MPR-162

## SWITCHING TEST CIRCUIT



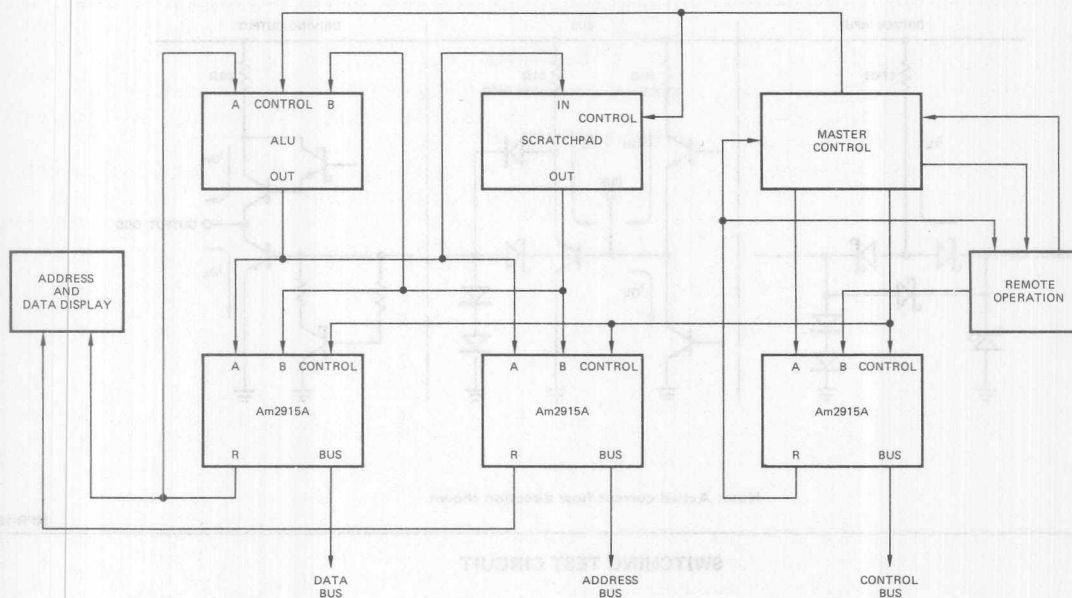
MPR-163

## SWITCHING WAVEFORMS



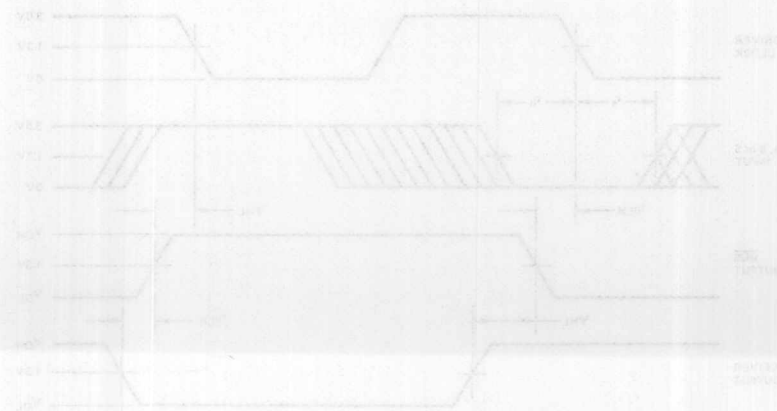
Note: Bus to Receiver output delay is measured by clocking data into the driver register and measuring the BUS to R combinatorial delay.

MPR-164



The Am2915A is a universal Bus Transceiver useful for many system data, address, control and timing input/output interfaces.

MPR-165



# Am2916A

## Quad Three-State Bus Transceiver With Interface Logic

### Distinctive Characteristics

- Quad high-speed LSI bus-transceiver
- Three-state bus driver
- Two-port input to D-type register on driver
- Bus driver output can sink 48mA at 0.5V max.
- Internal odd 4-bit parity checker/generator
- Receiver has output latch for pipeline operation
- Receiver outputs sink 12mA
- Advanced low-power Schottky processing
- 100% reliability assurance testing in compliance with MIL-STD-883
- 3.5V minimum output high voltage for direct interface to MOS microprocessors

### FUNCTIONAL DESCRIPTION

The Am2916A is a high-performance, low-power Schottky bus transceiver intended for bipolar or MOS microprocessor system applications. The device consists of four D-type edge-triggered flip-flops with a built-in two-input multiplexer on each. The flip-flop outputs are connected to four three-state bus drivers. Each bus driver is internally connected to the input of a receiver. The four receiver outputs drive four D-type latches. The device also contains a four-bit odd parity checker/generator.

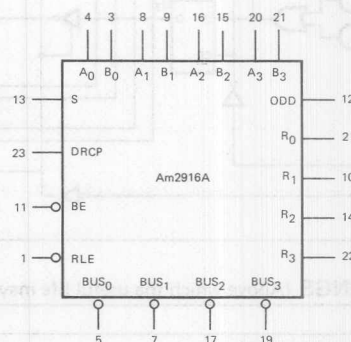
The LSI bus transceiver is fabricated using advanced low-power Schottky processing. All inputs (except the BUS inputs) are one LS unit load. The three-state bus output can sink up to 48mA at 0.5V maximum. The bus enable input ( $\overline{BE}$ ) is used to force the driver outputs to the high-impedance state. When  $\overline{BE}$  is HIGH, the driver is disabled.

The input register consists of four D-type flip-flops with a buffered common clock and a two-input multiplexer at the input of each flip-flop. A common select input (S) controls the four multiplexers. When S is LOW, the  $A_i$  data is stored in the register and when S is HIGH, the  $B_i$  data is stored. The buffered common clock (DRCP) enters the data into this driver register on the LOW-to-HIGH transition.

Data from the A or B input is inverted at the BUS output. Likewise, data at the BUS input is inverted at the receiver output. Thus, data is non-inverted from driver input to receiver output. The four receivers each feature a built-in D-type latch that is controlled from the buffered receiver latch enable (RLE) input. When the RLE input is LOW, the latch is open and the receiver outputs will follow the bus inputs (BUS data inverted). When the RLE input is HIGH, the latch will close and retain the present data regardless of the bus input.

The Am2916A features a built-in four-bit odd parity checker/generator. The bus enable input ( $\overline{BE}$ ) controls whether the parity output is in the generate or check mode. When the bus enable is LOW (driver enabled), odd parity is generated based on the A or B field data input to the driver register. When  $\overline{BE}$  is HIGH, the parity output is determined by the four latch outputs of the receiver. Thus, if the driver is enabled, parity is generated and if the driver is in the high-impedance state, the BUS parity is checked.

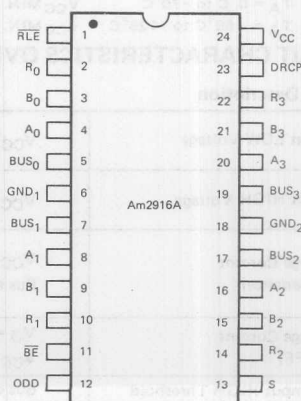
### LOGIC SYMBOL



$V_{CC}$  = Pin 24  
 $GND_1$  = Pin 6  
 $GND_2$  = Pin 18

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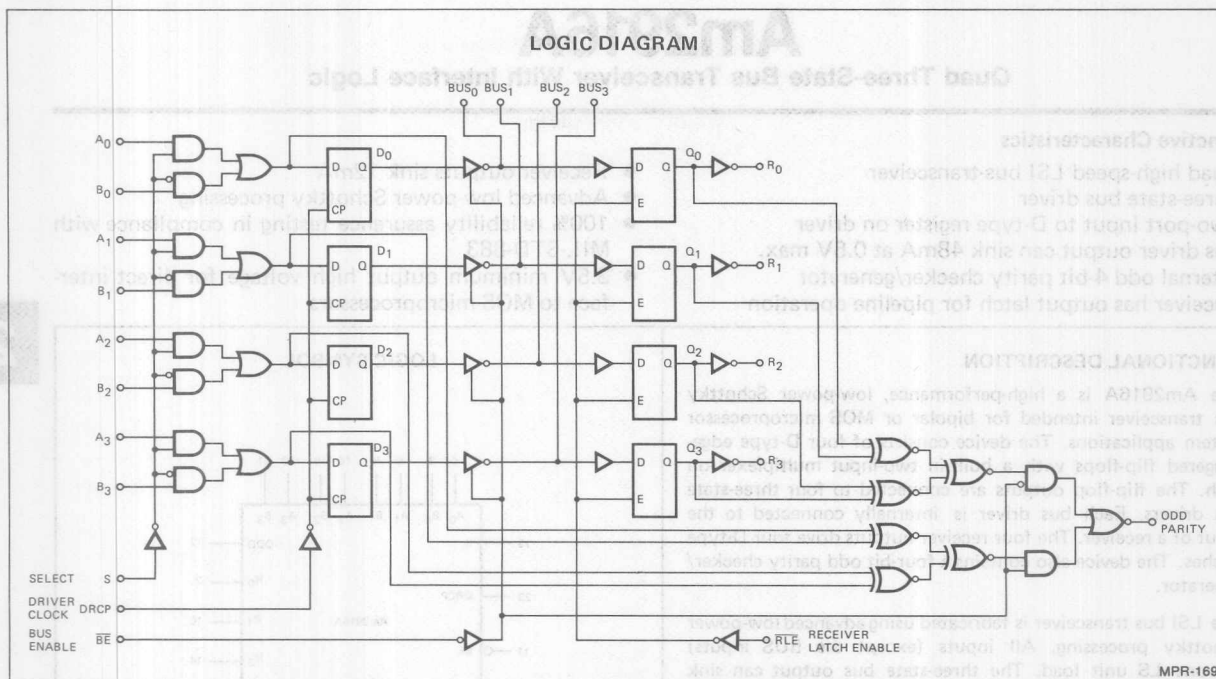
### CONNECTION DIAGRAM Top View



Note: Pin 1 is marked for orientation.

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**MAXIMUM RATINGS** (Above which the useful life may be impaired)

|   |                                |
|---|--------------------------------|
| Storage Temperature                                 | -65°C to +150°C                |
| Temperature (Ambient) Under Bias                    | -55°C to +125°C                |
| Supply Voltage to Ground Potential                  | -0.5V to +7V                   |
| DC Voltage Applied to Outputs for HIGH Output State | -0.5V to +V <sub>CC</sub> max. |
| DC Input Voltage                                    | -0.5V to +7V                   |
| DC Output Current, Into Outputs (Except Bus)        | 30mA                           |
| DC Output Current, Into Bus                         | 100mA                          |
| DC Input Current                                    | -30mA to +5.0mA                |

**ELECTRICAL CHARACTERISTICS**

The following conditions apply unless otherwise noted:

|                   |                                  |                              |                              |
|-------------------|----------------------------------|------------------------------|------------------------------|
| Am2916AXC (COM'L) | T <sub>A</sub> = 0°C to +70°C    | V <sub>CC</sub> MIN. = 4.75V | V <sub>CC</sub> MAX. = 5.25V |
| Am2916AXM (MIL)   | T <sub>A</sub> = -55°C to +125°C | V <sub>CC</sub> MIN. = 4.50V | V <sub>CC</sub> MAX. = 5.50V |

**BUS INPUT/OUTPUT CHARACTERISTICS OVER OPERATING TEMPERATURE RANGE**

| Parameters       | Description                          | Test Conditions (Note 1)                                 | Min. | Typ. | Max. | Units |
|------------------|--------------------------------------|--|------|------|------|-------|
| V <sub>OL</sub>  | Bus Output LOW Voltage               | V <sub>CC</sub> = MIN.<br>I <sub>OL</sub> = 24mA         |      |      | 0.4  | Volts |
|                  |                                      | I <sub>OL</sub> = 48mA                                   |      |      | 0.5  |       |
| V <sub>OH</sub>  | Bus Output HIGH Voltage              | V <sub>CC</sub> = MIN.<br>COM'L, I <sub>OH</sub> = -20mA | 2.4  |      |      | Volts |
|                  |                                      | MIL, I <sub>OH</sub> = -15mA                             |      |      |      |       |
| I <sub>O</sub>   | Bus Leakage Current (High Impedance) | V <sub>CC</sub> = MAX.<br>Bus enable = 2.4V              |      |      | -200 | μA    |
|                  |                                      | V <sub>O</sub> = 0.4V                                    |      |      | 50   |       |
|                  |                                      | V <sub>O</sub> = 2.4V                                    |      |      | 100  |       |
|                  |                                      | V <sub>O</sub> = 4.5V                                    |      |      |      |       |
| I <sub>OFF</sub> | Bus Leakage Current (Power OFF)      | V <sub>O</sub> = 4.5V<br>V <sub>CC</sub> = 0V            |      |      | 100  | μA    |
| V <sub>IH</sub>  | Receiver Input HIGH Threshold        | Bus enable = 2.4V  | 2.0  |      |      | Volts |
| V <sub>IL</sub>  | Receiver Input LOW Threshold         | Bus enable = 2.4V  |      |      | 0.8  | Volts |
|                  |                                      | COM'L  |      |      | 0.7  |       |
|                  |                                      | MIL  |      |      |      |       |
| I <sub>SC</sub>  | Bus Output Short Circuit Current     | V <sub>CC</sub> = MAX.<br>V <sub>O</sub> = 0V            | -50  | -120 | -225 | mA    |



## ELECTRICAL CHARACTERISTICS

The following conditions apply unless otherwise noted:

Am2916AXC (COM'L)  $T_A = 0^\circ\text{C to } +70^\circ\text{C}$   $V_{CC\text{MIN.}} = 4.75\text{ V}$   $V_{CC\text{MAX.}} = 5.25\text{ V}$   
 Am2916AXM (MIL)  $T_A = -55^\circ\text{C to } +125^\circ\text{C}$   $V_{CC\text{MIN.}} = 4.50\text{ V}$   $V_{CC\text{MAX.}} = 5.50\text{ V}$

## DC CHARACTERISTICS OVER OPERATING TEMPERATURE RANGE

| Parameters | Description                               | Test Conditions (Note 1)                                       |                                  | Min. | Typ.<br>(Note 2) | Max.  | Units         |
|------------|---|--|----------------------------------|------|------------------|-------|---------------|
| $V_{OH}$   | Receiver Output HIGH Voltage              | $V_{CC} = \text{MIN.}$   | MIL: $I_{OH} = -1.0\text{ mA}$   | 2.4  | 3.4              |       | Volts         |
|            |   | $V_{IN} = V_{IL} \text{ or } V_{IH}$                           | COM'L: $I_{OH} = -2.6\text{ mA}$ | 2.4  | 3.4              |       |               |
|            |   | $V_{CC} = 5.0\text{ V}, I_{OH} = -100\text{ }\mu\text{A}$      |                                  | 3.5  |                  |       |               |
| $V_{OH}$   | Parity Output HIGH Voltage                | $V_{CC} = \text{MIN.}, I_{OH} = -660\text{ }\mu\text{A}$       | MIL                              | 2.5  | 3.4              |       | Volts         |
|            |   | $V_{IN} = V_{IH} \text{ or } V_{IL}$                           | COM'L                            | 2.7  | 3.4              |       |               |
| $V_{OL}$   | Output LOW Voltage (Except Bus)           | $V_{CC} = \text{MIN.}$<br>$V_{IN} = V_{IL} \text{ or } V_{IH}$ | $I_{OL} = 4.0\text{ mA}$         |      | 0.27             | 0.4   | Volts         |
|            |   |  | $I_{OL} = 8.0\text{ mA}$         |      | 0.32             | 0.45  |               |
|            |   |  | $I_{OL} = 12\text{ mA}$          |      | 0.37             | 0.5   |               |
| $V_{IH}$   | Input HIGH Level (Except Bus)             | Guaranteed input logical HIGH for all inputs                   |                                  | 2.0  |                  |       | Volts         |
| $V_{IL}$   | Input LOW Level (Except Bus)              | Guaranteed input logical LOW for all inputs                    | MIL                              |      |                  | 0.7   | Volts         |
|            |   |  | COM'L                            |      |                  | 0.8   |               |
| $V_I$      | Input Clamp Voltage (Except Bus)          | $V_{CC} = \text{MIN.}, I_{IN} = -18\text{ mA}$                 |                                  |      |                  | -1.2  | Volts         |
| $I_{IL}$   | Input LOW Current (Except Bus)            | $V_{CC} = \text{MAX.}, V_{IN} = 0.4\text{ V}$                  | BE, RLE                          |      |                  | -0.72 | mA            |
|            |   |  | All other inputs                 |      |                  | -0.36 |               |
| $I_{IH}$   | Input HIGH Current (Except Bus)           | $V_{CC} = \text{MAX.}, V_{IN} = 2.7\text{ V}$                  |                                  |      |                  | 20    | $\mu\text{A}$ |
| $I_I$      | Input HIGH Current (Except Bus)           | $V_{CC} = \text{MAX.}, V_{IN} = 7.0\text{ V}$                  |                                  |      |                  | 100   | $\mu\text{A}$ |
| $I_{SC}$   | Output Short Circuit Current (Except Bus) | $V_{CC} = \text{MAX.}$   | RECEIVER                         | -30  |                  | -130  | mA            |
|            |   |  | PARITY                           | -20  |                  | -100  |               |
| $I_{CC}$   | Power Supply Current                      | $V_{CC} = \text{MAX.}, \text{All Inputs} = \text{GND}$         |                                  |      | 75               | 110   | mA            |

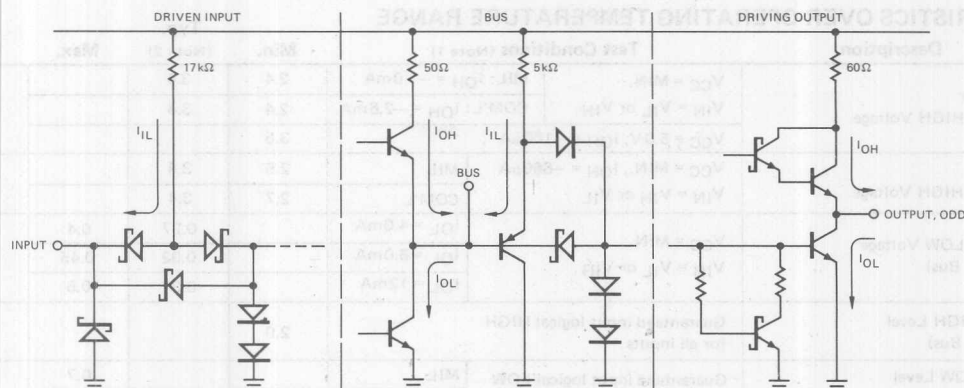
## SWITCHING CHARACTERISTICS OVER OPERATING TEMPERATURE RANGE

| Parameters       | Description  | Test Conditions   | Am2916AXM |                  |      | Am2916AXC |                  |      | Units |
|------------------|--|---|-----------|------------------|------|-----------|------------------|------|-------|
|                  |  |   | Min.      | Typ.<br>(Note 2) | Max. | Min.      | Typ.<br>(Note 2) | Max. |       |
| $t_{PHL}$        | Driver Clock (DRCP) to Bus                                 | $C_L (\text{BUS}) = 50\text{ pF}$<br>$R_L (\text{BUS}) = 130\text{ }\Omega$ | 21        | 36               |      | 21        | 32               |      | ns    |
| $t_{PLH}$        |  |   | 21        | 36               |      | 21        | 32               |      |       |
| $t_{ZH}, t_{ZL}$ | Bus Enable (BE) to Bus                                     |   | 13        | 26               |      | 13        | 23               |      | ns    |
| $t_{HZ}, t_{LZ}$ |  |   | 13        | 21               |      | 13        | 18               |      |       |
| $t_s$            | Data Inputs (A or B)                                       |   | 15        |                  |      | 12        |                  |      | ns    |
| $t_h$            |  |   | 8.0       |                  |      | 6.0       |                  |      |       |
| $t_s$            | Select Inputs (S)  |   | 28        |                  |      | 25        |                  |      | ns    |
| $t_h$            |  |   | 8.0       |                  |      | 6.0       |                  |      |       |
| $t_{PW}$         | Clock Pulse Width (HIGH)                                   |   | 20        |                  |      | 17        |                  |      | ns    |
| $t_{PLH}$        | Bus to Receiver Output (Latch Enabled)                     |   | 18        | 33               |      | 18        | 30               |      | ns    |
| $t_{PHL}$        |  |   | 18        | 30               |      | 18        | 27               |      |       |
| $t_{PLH}$        | Latch Enable to Receiver Output                            |   | 21        | 33               |      | 21        | 30               |      | ns    |
| $t_{PHL}$        |  |   | 21        | 30               |      | 21        | 27               |      |       |
| $t_s$            | Bus to Latch Enable (RLE)                                  | $C_L = 15\text{ pF}$<br>$R_L = 2.0\text{ k}\Omega$                          | 15        |                  |      | 13        |                  |      | ns    |
| $t_h$            |  |   | 6.0       |                  |      | 4.0       |                  |      |       |
| $t_{PLH}$        | A or B Data to Odd Parity Output (Driver Enabled)          |   | 32        | 46               |      | 32        | 42               |      | ns    |
| $t_{PHL}$        |  |   | 26        | 40               |      | 26        | 36               |      |       |
| $t_{PLH}$        | Bus to Odd Parity Output (Driver Inhibited, Latch Enabled) |   | 21        | 36               |      | 21        | 32               |      | ns    |
| $t_{PHL}$        |  |   | 21        | 36               |      | 21        | 32               |      |       |
| $t_{PLH}$        | Latch Enable (RLE) to Odd Parity Output                    |   | 21        | 36               |      | 21        | 32               |      | ns    |
| $t_{PHL}$        |  |   | 21        | 36               |      | 21        | 32               |      |       |

Notes: 1. For conditions shown as MIN. or MAX., use the appropriate value specified under Electrical Characteristics for the applicable device type.

2. Typical limits are at  $V_{CC} = 5.0\text{ V}$ ,  $25^\circ\text{C}$  ambient and maximum loading.

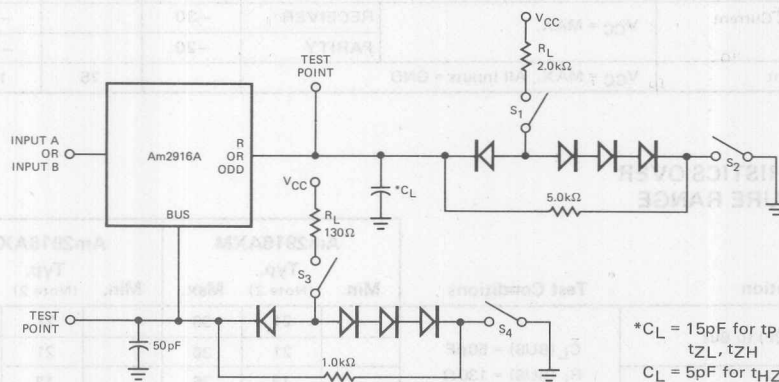
3. Not more than one output should be shorted at a time. Duration of the short circuit test should not exceed one second.



Note: Actual current flow direction shown.

MPR-170

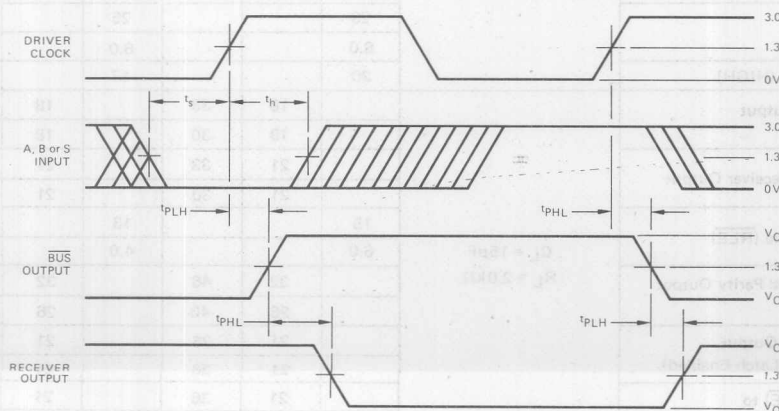
### SWITCHING TEST CIRCUIT



\* $C_L = 15\text{pF}$  for  $t_{PLH}$ ,  $t_{PHL}$ ,  $t_{ZL}$ ,  $t_{ZH}$   
 $C_L = 5\text{pF}$  for  $t_{HZ}$ ,  $t_{LZ}$

MPR-171

### SWITCHING WAVEFORMS



Note: Bus to Receiver output delay is measured by clocking data into the driver register and measuring the BUS to R combinatorial delay.

MPR-172

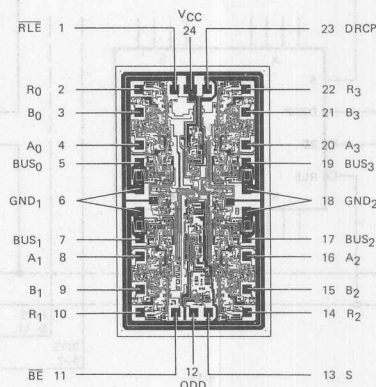


## FUNCTION TABLE

| INPUTS |                |                |      |    |     | INTERNAL TO DEVICE |                | BUS            | OUTPUT           | FUNCTION |  |
|--------|----------------|----------------|------|----|-----|--------------------|----------------|----------------|------------------|----------|--|
| S      | A <sub>i</sub> | B <sub>i</sub> | DRCP | BE | RLE | OE                 | D <sub>i</sub> | Q <sub>i</sub> | BUS <sub>i</sub> |          | R <sub>i</sub>                                       |
| X      | X              | X              | X    | H  | X   | X                  | X              | X              | Z                | X        | Driver output disable                                |
| X      | X              | X              | X    | X  | X   | H                  | X              | X              | X                | Z        | Receiver output disable                              |
| X      | X              | X              | X    | H  | L   | L                  | X              | L              | L                | H        | Driver output disable and receive data via Bus input |
| X      | X              | X              | X    | H  | L   | L                  | X              | H              | H                | L        |  |
| X      | X              | X              | X    | X  | H   | X                  | X              | NC             | X                | X        | Latch received data                                  |
| L      | L              | X              | ↑    | X  | X   | X                  | L              | X              | X                | X        | Load driver register                                 |
| L      | H              | X              | ↑    | X  | X   | X                  | H              | X              | X                | X        |  |
| H      | X              | L              | ↑    | X  | X   | X                  | L              | X              | X                | X        |  |
| H      | X              | H              | ↑    | X  | X   | X                  | H              | X              | X                | X        |  |
| X      | X              | X              | L    | X  | X   | X                  | NC             | X              | X                | X        | No driver clock restrictions                         |
| X      | X              | X              | H    | X  | X   | X                  | NC             | X              | X                | X        |  |
| X      | X              | X              | X    | L  | X   | X                  | L              | X              | H                | X        | Drive Bus  |
| X      | X              | X              | X    | L  | X   | X                  | H              | X              | L                | X        |  |

H = HIGH Z = HIGH Impedance X = Don't care i = 0, 1, 2, 3  
 L = LOW NC = No change ↑ = LOW to HIGH transition

## Metallization and Pad Layout



DIE SIZE .074" X .130"

## DEFINITION OF FUNCTIONAL TERMS

**A<sub>0</sub>, A<sub>1</sub>, A<sub>2</sub>, A<sub>3</sub>** The "A" word data input into the two input multiplexer of the driver register.

**B<sub>0</sub>, B<sub>1</sub>, B<sub>2</sub>, B<sub>3</sub>** The "B" word data input into the two input multiplexers of the driver register.

**S** Select. When the select input is LOW, the A data word is applied to the driver register. When the select input is HIGH, the B word is applied to the driver register.

**DRCP** Driver Clock Pulse. Clock pulse for the driver register.

**BE** Bus Enable. When the Bus Enable is HIGH, the four drivers are in the high impedance state.

**BUS<sub>0</sub>, BUS<sub>1</sub>, BUS<sub>2</sub>, BUS<sub>3</sub>** The four driver outputs and receiver inputs (data is inverted).

**R<sub>0</sub>, R<sub>1</sub>, R<sub>2</sub>, R<sub>3</sub>** The four receiver outputs. Data from the bus is inverted while data from the A or B inputs is non-inverted.

**RLE** Receiver Latch Enable. When  $\overline{RLE}$  is LOW, data on the BUS inputs is passed through the receiver latches. When  $\overline{RLE}$  is HIGH, the receiver latches are closed and will retain the data independent of all other inputs.

**OE** Output Enable. When the  $\overline{OE}$  input is HIGH, the four three state receiver outputs are in the high-impedance state.

## ORDERING INFORMATION

Order the part number according to the table below to obtain the desired package, temperature range, and screening level.

| Order Number | Package Type<br>(Note 1) | Operating Range<br>(Note 2) | Screening Level<br>(Note 3)                          |
|--------------|--------------------------|-----------------------------|--|
| AM2916APC    | P-24                     | C                           | C-1  |
| AM2916ADC    | D-24                     | C                           | C-1  |
| AM2916ADC-B  | D-24                     | C                           | B-1  |
| AM2916ADM    | D-24                     | M                           | C-3  |
| AM2916ADM-B  | D-24                     | M                           | B-3  |
| AM2916AFM    | F-24-1                   | M                           | C-3  |
| AM2916AFM-B  | F-24-1                   | M                           | B-3  |
| AM2916AXC    | Dice                     | C                           | Visual inspection<br>to MIL-STD-883<br>Method 2010B. |
| AM2916AXM    | Dice                     | M                           |  |

Notes: 1. P = Molded DIP, D = Hermetic DIP, F = Flat Pak. Number following letter is number of leads. See Appendix B for detailed outline. Where Appendix B contains several dash numbers, any of the variations of the package may be used unless otherwise specified.  
 2. C = 0°C to +70°C, V<sub>CC</sub> = 4.75V to 5.25V, M = -55°C to +125°C, V<sub>CC</sub> = 4.50V to 5.50V.  
 3. See Appendix A for details of screening. Levels C-1 and C-3 conform to MIL-STD-883, Class C. Level B-3 conforms to MIL-STD-883, Class B.



# Am2917A

## Quad Three-State Bus Transceiver With Interface Logic

### Distinctive Characteristics

- Quad high-speed LSI bus-transceiver
- Three-state bus driver
- D-type register on driver
- Bus driver output can sink 48mA at 0.5V max.
- Internal odd 4-bit parity checker/generator
- Receiver has output latch for pipeline operation
- Three-state receiver outputs sink 12mA
- Advanced low-power Schottky processing
- 100% reliability assurance testing in compliance with MIL-STD-883
- 3.5V minimum output high voltage for direct interface to MOS microprocessors

### FUNCTIONAL DESCRIPTION

The Am2917A is a high-performance, low-power Schottky bus transceiver intended for bipolar or MOS microprocessor system applications. The device consists of four D-type edge-triggered flip-flops. The flip-flop outputs are connected to four three-state bus drivers. Each bus driver is internally connected to the input of a receiver. The four receiver outputs drive four D-type latches, that feature three-state outputs. The device also contains a four-bit odd parity checker/generator.

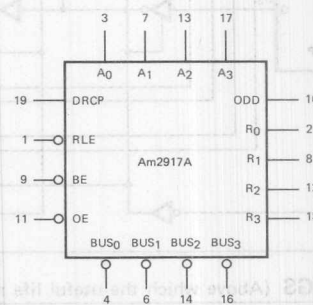
The LSI bus transceiver is fabricated using advanced low-power Schottky processing. All inputs (except the BUS inputs) are one LS unit load. The three-state bus output can sink up to 48mA at 0.5V maximum. The bus enable input ( $\overline{BE}$ ) is used to force the driver outputs to the high-impedance state. When  $\overline{BE}$  is HIGH, the driver is disabled.

The input register consists of four D-type flip-flops with a buffered common clock. The buffered common clock (DRCP) enters the  $A_i$  data into this driver register on the LOW-to-HIGH transition.

Data from the A input is inverted at the BUS output. Likewise, data at the BUS input is inverted at the receiver output. Thus, data is non-inverted from driver input to receiver output. The four receivers each feature a built-in D-type latch that is controlled from the buffered receiver latch enable ( $\overline{RLE}$ ) input. When the  $\overline{RLE}$  input is LOW, the latch is open and the receiver outputs will follow the bus inputs (BUS data inverted and  $\overline{OE}$  LOW). When the  $\overline{RLE}$  input is HIGH, the latch will close and retain the present data regardless of the bus input. The four latches have three-state outputs and are controlled by a buffered common three-state control ( $\overline{OE}$ ) input. When  $\overline{OE}$  is HIGH, the receiver outputs are in the high-impedance state.

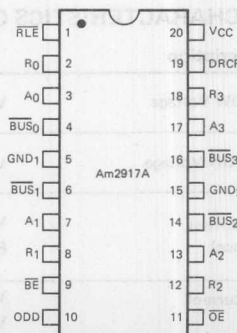
The Am2917A features a built-in four-bit odd parity checker/generator. The bus enable input ( $\overline{BE}$ ) controls whether the parity output is in the generate or check mode. When the bus enable is LOW (driver enabled), odd parity is generated based on the A field data input to the driver register. When  $\overline{BE}$  is HIGH, the parity output is determined by the four latch outputs of the receiver. Thus, if the driver is enabled, parity is generated and if the driver is in the high-impedance state, the BUS parity is checked.

### LOGIC SYMBOL



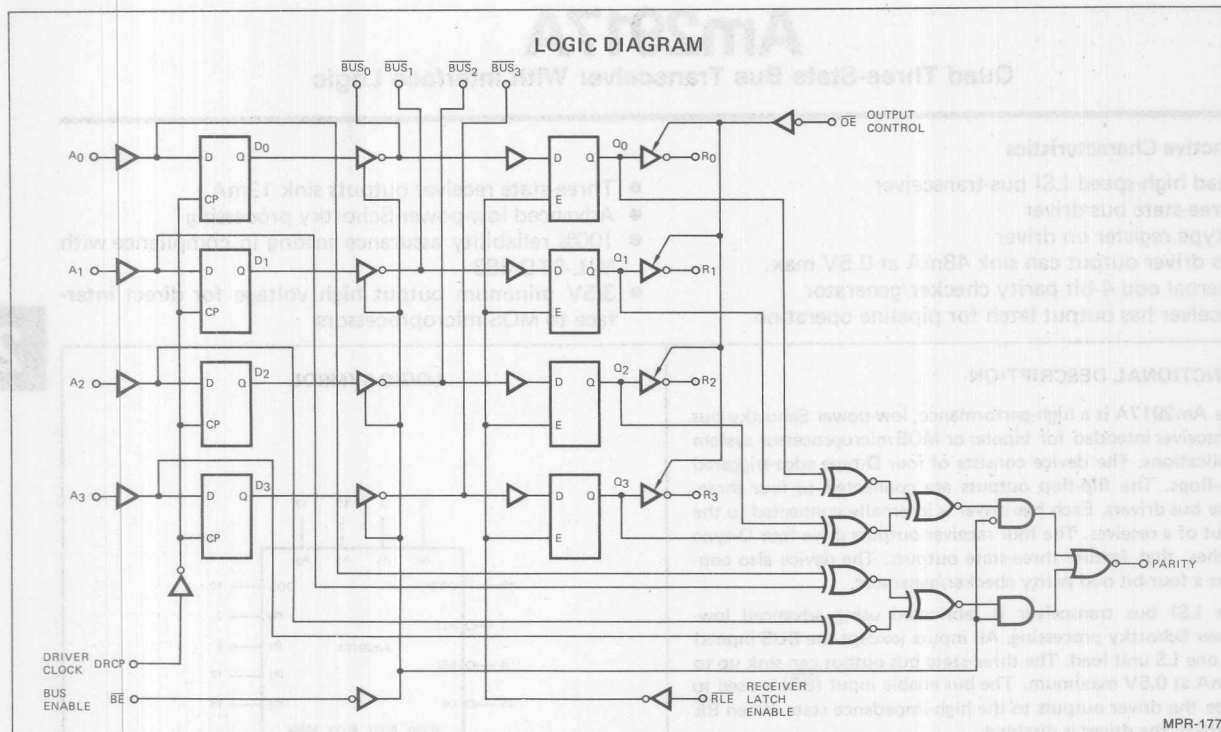
$V_{CC}$  = Pin 20  
 $GND_1$  = Pin 5  
 $GND_2$  = Pin 15

### CONNECTION DIAGRAM Top View



Note: Pin 1 is marked for orientation.

2



**MAXIMUM RATINGS** (Above which the useful life may be impaired)

|   |                                 |
|---|---------------------------------|
| Storage Temperature                                 | -65°C to +150°C                 |
| Temperature (Ambient) Under Bias                    | -55°C to +125°C                 |
| Supply Voltage to Ground Potential                  | -0.5 V to +7 V                  |
| DC Voltage Applied to Outputs for HIGH Output State | -0.5 V to +V <sub>CC</sub> max. |
| DC Input Voltage                                    | -0.5 V to +7 V                  |
| DC Output Current, Into Outputs (Except BUS)        | 30 mA                           |
| DC Output Current, Into Bus                         | 100 mA                          |
| DC Input Current                                    | -30 mA to +5.0 mA               |

## ELECTRICAL CHARACTERISTICS

The following conditions apply unless otherwise noted:

|                   |  |                                      |                                      |
|-------------------|--|--------------------------------------|--------------------------------------|
| Am2917AXC (COM'L) | $T_A = 0^{\circ}\text{C to } +70^{\circ}\text{C}$    | $V_{CC\text{ MIN.}} = 4.75\text{ V}$ | $V_{CC\text{ MAX.}} = 5.25\text{ V}$ |
| Am2917AXM (MIL)   | $T_A = -55^{\circ}\text{C to } +125^{\circ}\text{C}$ | $V_{CC\text{ MIN.}} = 4.50\text{ V}$ | $V_{CC\text{ MAX.}} = 5.50\text{ V}$ |

## BUS INPUT/OUTPUT CHARACTERISTICS OVER OPERATING TEMPERATURE RANGE

| Parameters       | Description                             | Test Conditions (Note 1)                        |                                 | Min. | Typ. | Max. | Units |
|------------------|---|---|---------------------------------|------|------|------|-------|
| V <sub>OL</sub>  | Bus Output LOW Voltage                  | V <sub>CC</sub> = MIN.                          | I <sub>OL</sub> = 24 mA         |      |      | 0.4  | Volts |
|                  |   |   | I <sub>OL</sub> = 48 mA         |      |      | 0.5  |       |
| V <sub>OH</sub>  | Bus Output HIGH Voltage                 | V <sub>CC</sub> = MIN.                          | COM'L, I <sub>OH</sub> = -20 mA | 2.4  |      |      | Volts |
|                  |   |   | MIL, I <sub>OH</sub> = -15 mA   |      |      |      |       |
| I <sub>O</sub>   | Bus Leakage Current<br>(High Impedance) | V <sub>CC</sub> = MAX.<br>Bus enable = 2.4 V    | V <sub>O</sub> = 0.4 V          |      |      | -200 | μA    |
|                  |   |   | V <sub>O</sub> = 2.4 V          |      |      | 50   |       |
|                  |   |   | V <sub>O</sub> = 4.5 V          |      |      | 100  |       |
| I <sub>OFF</sub> | Bus Leakage Current<br>(Power OFF)      | V <sub>O</sub> = 4.5 V<br>V <sub>CC</sub> = 0 V |                                 |      |      | 100  | μA    |
| V <sub>IH</sub>  | Receiver Input HIGH Threshold           | Bus enable = 2.4 V                              |                                 | 2.0  |      |      | Volts |
| V <sub>IL</sub>  | Receiver Input LOW Threshold            | Bus enable = 2.4 V                              | COM'L                           |      |      | 0.8  | Volts |
|                  |   |   | MIL                             |      |      | 0.7  |       |
| I <sub>SC</sub>  | Bus Output Short Circuit Current        | V <sub>CC</sub> = MAX.<br>V <sub>O</sub> = 0 V  |                                 | -50  | -120 | -225 | mA    |

## ELECTRICAL CHARACTERISTICS

The following conditions apply unless otherwise noted:

Am2917AXC (COM'L)  $T_A = 0^\circ\text{C to } +70^\circ\text{C}$   $V_{CC\text{ MIN.}} = 4.75\text{ V}$   $V_{CC\text{ MAX.}} = 5.25\text{ V}$ Am2917AXM (MIL)  $T_A = -55^\circ\text{C to } +125^\circ\text{C}$   $V_{CC\text{ MIN.}} = 4.50\text{ V}$   $V_{CC\text{ MAX.}} = 5.50\text{ V}$ 

## DC CHARACTERISTICS OVER OPERATING TEMPERATURE RANGE

| Parameters | Description                                    | Test Conditions (Note 1)   | Min.   | Typ.<br>(Note 2) | Max.  | Units         |
|------------|--|--|--|------------------|-------|---------------|
| $V_{OH}$   | Receiver Output HIGH Voltage                   | $V_{CC} = \text{MIN.}$<br>$V_{IN} = V_{IL} \text{ or } V_{IH}$                                   | MIL: $I_{OH} = -1.0\text{ mA}$<br>COM'L: $I_{OH} = -2.6\text{ mA}$ | 2.4              | 3.4   | Volts         |
|            |  | $V_{CC} = 5.0\text{ V}, I_{OH} = -100\text{ }\mu\text{A}$  |  | 3.5              |       |               |
|            |  | $V_{CC} = \text{MIN.}, I_{OH} = -660\text{ }\mu\text{A}$<br>$V_{IN} = V_{IH} \text{ or } V_{IL}$ | MIL<br>COM'L   | 2.5<br>2.7       | 3.4   |               |
| $V_{OL}$   | Output LOW Voltage<br>(Except Bus)             | $V_{CC} = \text{MIN.}$<br>$V_{IN} = V_{IL} \text{ or } V_{IH}$                                   | $I_{OL} = 4.0\text{ mA}$   |                  | 0.27  | Volts         |
|            |  |  | $I_{OL} = 8.0\text{ mA}$   |                  | 0.32  |               |
|            |  |  | $I_{OL} = 12\text{ mA}$  |                  | 0.37  |               |
| $V_{IH}$   | Input HIGH Level<br>(Except Bus)               | Guaranteed input logical HIGH<br>for all inputs  | 2.0  |                  |       | Volts         |
| $V_{IL}$   | Input LOW Level<br>(Except Bus)                | Guaranteed input logical LOW<br>for all inputs   | MIL  |                  | 0.7   | Volts         |
|            |  |  | COM'L  |                  | 0.8   |               |
| $V_I$      | Input Clamp Voltage (Except Bus)               | $V_{CC} = \text{MIN.}, I_{IN} = -18\text{ mA}$   |  |                  | -1.2  | Volts         |
| $I_{IL}$   | Input LOW Current (Except Bus)                 | $V_{CC} = \text{MAX.}, V_{IN} = 0.4\text{ V}$  | $\overline{BE}, \overline{RLE}$                                    |                  | -0.72 | mA            |
|            |  |  | All other inputs   |                  | -0.36 |               |
| $I_{IH}$   | Input HIGH Current (Except Bus)                | $V_{CC} = \text{MAX.}, V_{IN} = 2.7\text{ V}$  |  |                  | 20    | $\mu\text{A}$ |
| $I_I$      | Input HIGH Current (Except Bus)                | $V_{CC} = \text{MAX.}, V_{IN} = 7.0\text{ V}$  |  |                  | 100   | $\mu\text{A}$ |
| $I_{SC}$   | Output Short Circuit Current<br>(Except Bus)   | $V_{CC} = \text{MAX.}$   | RECEIVER   | -30              | -130  | mA            |
|            |  |  | PARITY   | -20              | -100  |               |
| $I_{CC}$   | Power Supply Current                           | $V_{CC} = \text{MAX.}$   |  | 63               | 95    | mA            |
| $I_O$      | Off-State Output Current<br>(Receiver Outputs) | $V_{CC} = \text{MAX.}$   | $V_O = 2.4\text{ V}$   |                  | 50    | $\mu\text{A}$ |
|            |  |  | $V_O = 0.4\text{ V}$   |                  | -50   |               |

2

SWITCHING CHARACTERISTICS OVER  
OPERATING TEMPERATURE RANGE

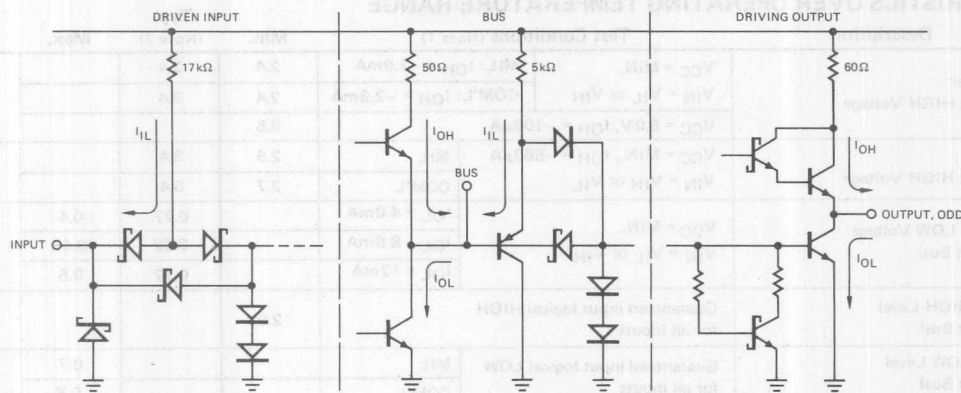
| Parameters       | Description   | Test Conditions   | Am2917AXM |                  |      | Am2917AXC |                  |      | Units |
|------------------|---|---|-----------|------------------|------|-----------|------------------|------|-------|
|                  |   |   | Min.      | Typ.<br>(Note 2) | Max. | Min.      | Typ.<br>(Note 2) | Max. |       |
| $t_{PHL}$        | Driver Clock (DRCP) to Bus                                | $C_L (\text{BUS}) = 50\text{ pF}$<br>$R_L (\text{BUS}) = 130\text{ }\Omega$ |           | 21               | 36   |           | 21               | 32   | ns    |
| $t_{PLH}$        |   |   |           | 21               | 36   |           | 21               | 32   |       |
| $t_{ZH}, t_{ZL}$ |   |   |           | 13               | 26   |           | 13               | 23   |       |
| $t_{HZ}, t_{LZ}$ | Bus Enable ( $\overline{BE}$ ) to Bus                     |   |           | 13               | 21   |           | 13               | 18   | ns    |
| $t_s$            | A Data Inputs   |   | 15        |                  |      | 12        |                  |      | ns    |
| $t_h$            |   |   | 8.0       |                  |      | 6.0       |                  |      |       |
| $t_{PW}$         | Clock Pulse Width (HIGH)                                  |   | 20        |                  |      | 17        |                  |      | ns    |
| $t_{PLH}$        | Bus to Receiver Output<br>(Latch Enabled)                 |   |           | 18               | 33   |           | 18               | 30   | ns    |
| $t_{PHL}$        |   |   |           | 18               | 30   |           | 18               | 27   |       |
| $t_{PLH}$        | Latch Enable to Receiver Output                           |   |           | 21               | 33   |           | 21               | 30   | ns    |
| $t_{PHL}$        |   |   |           | 21               | 30   |           | 21               | 27   |       |
| $t_s$            | Bus to Latch Enable ( $\overline{RLE}$ )                  | $C_L = 15\text{ pF}$<br>$R_L = 2.0\text{ k}\Omega$                          | 15        |                  |      | 13        |                  |      | ns    |
| $t_h$            |   |   | 6.0       |                  |      | 4.0       |                  |      |       |
| $t_{PLH}$        | A Data to Odd Parity Out<br>(Driver Enabled)              |   |           | 32               | 46   |           | 32               | 42   | ns    |
| $t_{PHL}$        |   |   |           | 26               | 40   |           | 26               | 36   |       |
| $t_{PLH}$        | Bus to Odd Parity Out<br>(Driver Inhibit)                 |   |           | 21               | 36   |           | 21               | 32   | ns    |
| $t_{PHL}$        |   |   |           | 21               | 36   |           | 21               | 32   |       |
| $t_{PLH}$        | Latch Enable ( $\overline{RLE}$ ) to Odd<br>Parity Output |   |           | 21               | 36   |           | 21               | 32   | ns    |
| $t_{PHL}$        |   |   |           | 21               | 36   |           | 21               | 32   |       |
| $t_{ZH}, t_{ZL}$ | Output Control to Output                                  | $C_L = 5\text{ pF}, R_L = 2.0\text{ k}\Omega$                               |           | 14               | 26   |           | 14               | 23   | ns    |
| $t_{HZ}, t_{LZ}$ |   |   |           | 14               | 26   |           | 14               | 23   |       |

Notes: 1. For conditions shown as MIN. or MAX., use the appropriate value specified under Electrical Characteristics for the applicable device type.

2. Typical limits are at  $V_{CC} = 5.0\text{ V}$ ,  $25^\circ\text{C}$  ambient and maximum loading.

3. Not more than one output should be shorted at a time. Duration of the short circuit test should not exceed one second.

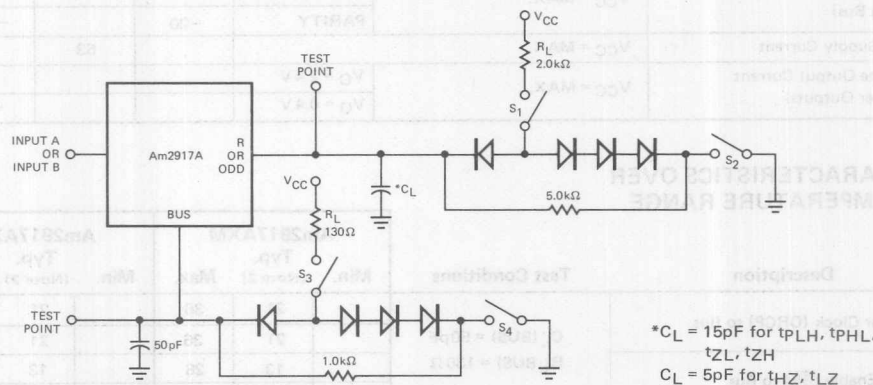
# INPUT/OUTPUT CURRENT INTERFACE CONDITIONS



Note: Actual current flow direction shown.

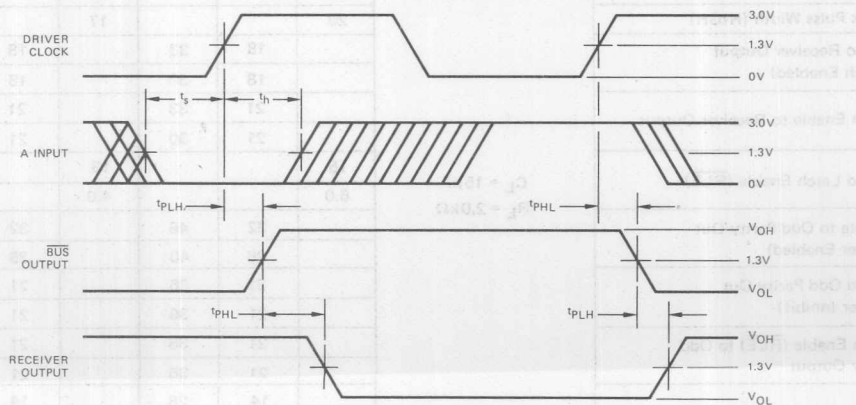
MPR-178

## SWITCHING TEST CIRCUIT



MPR-179

## SWITCHING WAVEFORMS

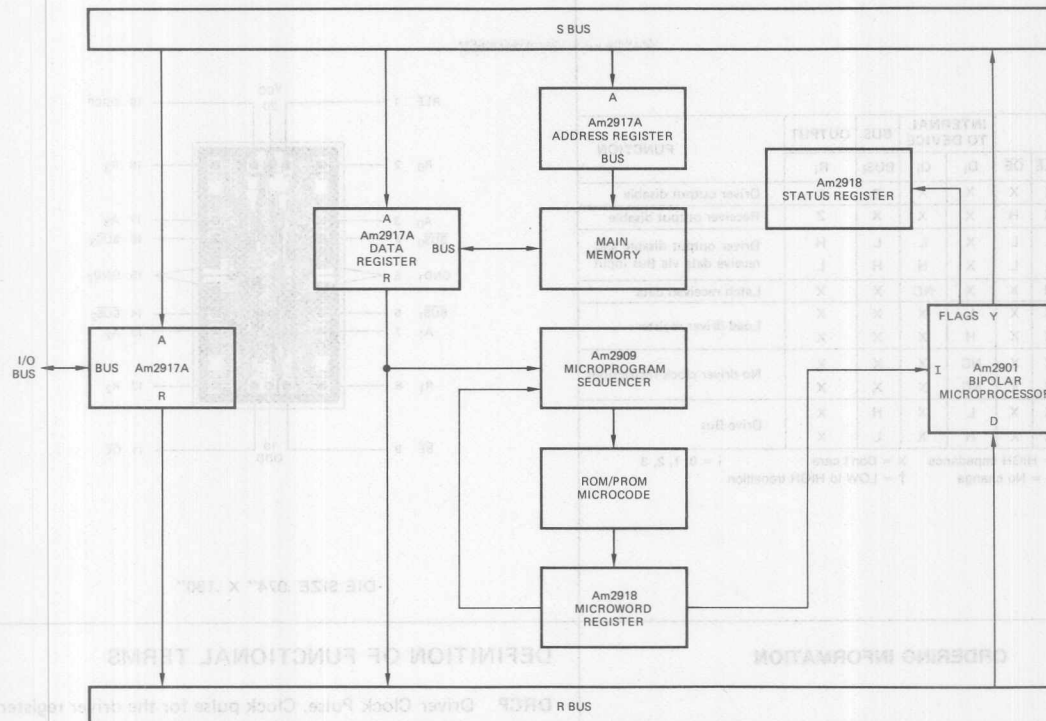


Note: Bus to Receiver output delay is measured by clocking data into the driver register and measuring the BUS to R combinatorial delay.

MPR-180



## APPLICATIONS



The Am2917A can be used as an I/O Bus Transceiver and Main Memory I/O Transceiver in high-speed Microprocessor Systems.

## PARITY OUTPUT FUNCTION TABLE

| BE | ODD PARITY OUTPUT                            |
|----|--|
| L  | $ODD = A_0 \oplus A_1 \oplus A_2 \oplus A_3$ |
| H  | $ODD = D_0 \oplus D_1 \oplus D_2 \oplus D_3$ |

## MPR-181

| Order Number | Package Type (Note 1) | Operating Range (Note 2) | Screening Level (Note 3)     |
|--------------|-----------------------|--------------------------|------------------------------|
| AM2917AFC    | P-50                  | C                        | C-1                          |
| AM2917ADC    | D-50                  | C                        | C-1                          |
| AM2917ADC-8  | D-50                  | C                        | B-1                          |
| AM2917ADM    | D-50                  | M                        | B-3                          |
| AM2917ADM-8  | D-50                  | M                        | B-3                          |
| AM2917AFB    | P-50                  | M                        | C-3                          |
| AM2917AFB-8  | P-50                  | M                        | B-3                          |
| AM2917AXC    | Disc                  | C                        | Visual inspection            |
| AM2917AXM    | Disc                  | M                        | to MIL-STD-883C Method 2010B |

Notes:  
 1. P = Molded DIP, D = Hermetic DIP, F = Flip Pak. Number follow and letter is number of leads. See Appendix B for detailed outline.  
 2. C = 0°C to +70°C, V<sub>CC</sub> = 4.5V to 5.25V.  
 M = -55°C to +125°C, V<sub>CC</sub> = 4.5V to 5.5V.  
 3. See Appendix A for details of screening. Levels C-1 and B-3 conform to MIL-STD-883, Class B. Level B-3 conforms to MIL-STD-883, Class B.

| INPUTS         |      |                 |                  | INTERNAL TO DEVICE |                | BUS            | OUTPUT           | FUNCTION |  |
|----------------|------|-----------------|------------------|--------------------|----------------|----------------|------------------|----------|--|
| A <sub>i</sub> | DRCP | $\overline{BE}$ | $\overline{RLE}$ | $\overline{OE}$    | D <sub>i</sub> | Q <sub>i</sub> | BUS <sub>i</sub> |          | R <sub>i</sub>                                       |
| X              | X    | H               | X                | X                  | X              | X              | X                | Z        | Driver output disable                                |
| X              | X    | X               | X                | H                  | X              | X              | X                | Z        | Receiver output disable                              |
| X              | X    | H               | L                | L                  | X              | L              | L                | H        | Driver output disable and receive data via Bus input |
| X              | X    | H               | L                | L                  | X              | H              | H                | L        | Driver output disable and receive data via Bus input |
| X              | X    | X               | H                | X                  | X              | NC             | X                | X        | Latch received data                                  |
| L              | ↑    | X               | X                | X                  | L              | X              | X                | X        | Load driver register                                 |
| H              | ↑    | X               | X                | X                  | H              | X              | X                | X        | Load driver register                                 |
| X              | L    | X               | X                | X                  | NC             | X              | X                | X        | No driver clock restrictions                         |
| X              | H    | X               | X                | X                  | NC             | X              | X                | X        | No driver clock restrictions                         |
| X              | X    | L               | X                | X                  | L              | X              | H                | X        | Drive Bus  |
| X              | X    | L               | X                | X                  | H              | X              | L                | X        | Drive Bus  |

H = HIGH  
L = LOW

Z = HIGH Impedance  
NC = No change

X = Don't care  
↑ = LOW to HIGH transition

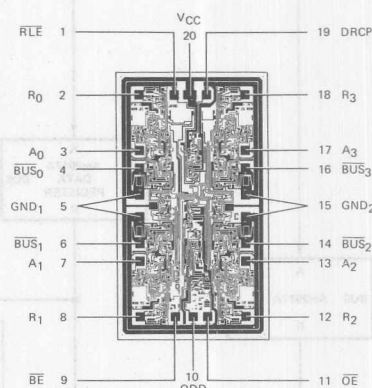
i = 0, 1, 2, 3

H = HIGH  
L = LOW

Z = HIGH Impedance  
NC = No change

X = Don't care  
↑ = LOW to HIGH transition

i = 0, 1, 2, 3



DIE SIZE .074" X .130"

### ORDERING INFORMATION

Order the part number according to the table below to obtain the desired package, temperature range, and screening level.

| Order Number | Package Type (Note 1) | Operating Range (Note 2) | Screening Level (Note 3)                       |
|--------------|-----------------------|--------------------------|--|
| AM2917APC    | P-20                  | C                        | C-1  |
| AM2917ADC    | D-20                  | C                        | C-1  |
| AM2917ADC-B  | D-20                  | C                        | B-1  |
| AM2917ADM    | D-20                  | M                        | C-3  |
| AM2917ADM-B  | D-20                  | M                        | B-3  |
| AM2917AFM    | F-20                  | M                        | C-3  |
| AM2917AFM-B  | F-20                  | M                        | B-3  |
| AM2917AXC    | Dice                  | C                        | Visual inspection to MIL-STD-883 Method 2010B. |
| AM2917AXM    | Dice                  | M                        |  |

#### Notes:

- P = Molded DIP, D = Hermetic DIP, F = Flat Pak. Number following letter is number of leads. See Appendix B for detailed outline. Where Appendix B contains several dash numbers, any of the variations of the package may be used unless otherwise specified.
- C = 0°C to +70°C, V<sub>CC</sub> = 4.75V to 5.25V.  
M = -55°C to +125°C, V<sub>CC</sub> = 4.50V to 5.50V.
- See Appendix A for details of screening. Levels C-1 and C-3 conform to MIL-STD-883, Class C. Level B-3 conforms to MIL-STD-883, Class B.

### DEFINITION OF FUNCTIONAL TERMS

**DRCP** Driver Clock Pulse. Clock pulse for the driver register.

**$\overline{BE}$**  Bus Enable. When the Bus Enable is HIGH, the four drivers are in the high impedance state.

**BUS<sub>0</sub>, BUS<sub>1</sub>, BUS<sub>2</sub>, BUS<sub>3</sub>** The four driver outputs and receiver inputs (data is inverted).

**R<sub>0</sub>, R<sub>1</sub>, R<sub>2</sub>, R<sub>3</sub>** The four receiver outputs. Data from the bus is inverted while data from the A inputs is non-inverted.

**$\overline{RLE}$**  Receiver Latch Enable. When  $\overline{RLE}$  is LOW, data on the BUS inputs is passed through the receiver latches. When  $\overline{RLE}$  is HIGH, the receiver latches are closed and will retain the data independent of all other inputs.

**ODD** Odd parity output. Generates parity with the driver enabled, checks parity with the driver in the high-impedance state.

**$\overline{OE}$**  Output Enable. When the  $\overline{OE}$  input is HIGH, the four three-state receiver outputs are in the high-impedance state.

### PARITY OUTPUT FUNCTION TABLE

| $\overline{BE}$ | ODD PARITY OUTPUT   |
|-----------------|---|
| L               | ODD = A <sub>0</sub> ⊕ A <sub>1</sub> ⊕ A <sub>2</sub> ⊕ A <sub>3</sub> |
| H               | ODD = Q <sub>0</sub> ⊕ Q <sub>1</sub> ⊕ Q <sub>2</sub> ⊕ Q <sub>3</sub> |

### Quad D Register With Standard And Three-State Outputs

### Distinctive Characteristics

- Advanced Schottky technology
- Four D-type flip-flops
- Four standard totem-pole outputs

- Four three-state outputs
- 75 MHz clock frequency
- 100% reliability assurance testing in compliance with MIL-STD-883

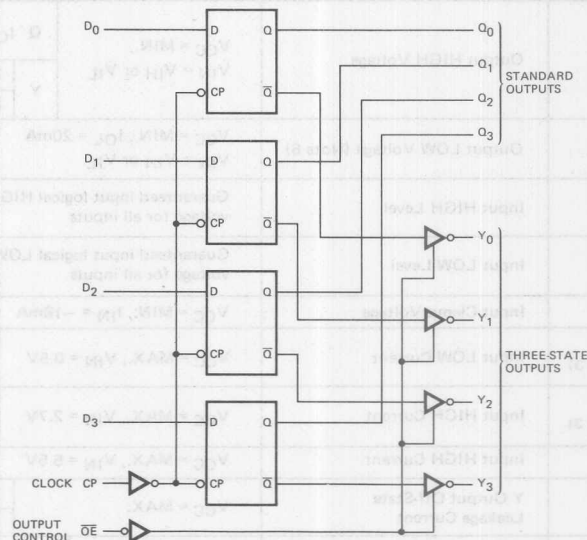
## FUNCTIONAL DESCRIPTION

New Schottky circuits such as the Am2918 register provide the design engineer with additional flexibility in system configuration — especially with regard to bus structure, organization and speed. The Am2918 is a quadruple D-type register with four standard totem pole outputs and four three-state bus-type outputs. The 16-pin device also features a buffered common clock (CP) and a buffered common output control ( $\overline{OE}$ ) for the Y outputs. Information meeting the set-up and hold requirements on the D inputs is transferred to the Q outputs on the LOW-to-HIGH transition of the clock.

The same data as on the Q outputs is enabled at the three-state Y outputs when the "output control" ( $\overline{OE}$ ) input is LOW. When the  $\overline{OE}$  input is HIGH, the Y outputs are in the high-impedance state.

The Am2918 register can be used in bipolar microprocessor designs as an address register, status register, instruction register or for various data or microword register applications. Because of the unique design of the three-state output, the device features very short propagation delay from the clock to the Q or Y outputs. Thus, system performance and architectural design can be improved by using the Am2918 register. Other applications of Am2918 register can be found in microprogrammed display systems, communication systems and most general or special purpose digital signal processing equipment.

### LOGIC DIAGRAM



MPR-183

## ORDERING INFORMATION

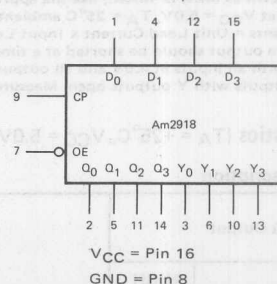
Order the part number according to the table below to obtain the desired package, temperature range, and screening level.

| Order Number | Package Type<br>(Note 1) | Operating Range<br>(Note 2) | Screening Level<br>(Note 3)                          |
|--------------|--------------------------|-----------------------------|--|
| AM2918PC     | P-16                     | C                           | C-1  |
| AM2918DC     | D-16                     | C                           | C-1  |
| AM2918DC-B   | D-16                     | C                           | B-1  |
| AM2918DM     | D-16                     | M                           | C-3  |
| AM2918DM-B   | D-16                     | M                           | B-3  |
| AM2918FM     | F-16                     | M                           | C-3  |
| AM2918FM-B   | F-16                     | M                           | B-3  |
| AM2918XC     | Dice                     | C                           | Visual inspection<br>to MIL-STD-883<br>Method 2010B. |
| AM2918XM     | Dice                     | M                           |  |

Notes:

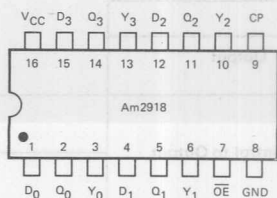
1. P = Molded DIP, D = Hermetic DIP, F = Flat Pak. Number following letter is number of leads. See Appendix B for detailed outline. Where Appendix B contains several dash numbers, any of the variations of the package may be used unless otherwise specified.
2. C = 0°C to +70°C, V<sub>CC</sub> = 4.75V to 5.25V.  
M = -55°C to +125°C, V<sub>CC</sub> = 4.50V to 5.50V.
3. See Appendix A for details of screening. Levels C-1 and C-3 conform to MIL-STD-883, Class C. Level B-3 conforms to MIL-STD-883, Class B.

LOGIC SYMBOL



MPR-184

CONNECTION DIAGRAM  
Top View



Note: Pin 1 is marked for orientation.

MPR-185

# Am2918

## MAXIMUM RATINGS (Above which the useful life may be impaired)

|   |                                |
|---|--------------------------------|
| Storage Temperature   | -65°C to +150°C                |
| Temperature (Ambient) Under Bias                                | -55°C to +125°C                |
| Supply Voltage to Ground Potential (Pin 16 to Pin 8) Continuous | -0.5V to +7V                   |
| DC Voltage Applied to Outputs for HIGH Output State             | -0.5V to +V <sub>CC</sub> max. |
| DC Input Voltage  | -0.5V to +5.5V                 |
| DC Output Current, Into Outputs                                 | 30mA                           |
| DC Input Current  | -30mA to +5.0mA                |

## ELECTRICAL CHARACTERISTICS OVER OPERATING TEMPERATURE RANGE (Unless Otherwise Noted)

| Am2918XC                 | T <sub>A</sub> = 0°C to +70°C         | V <sub>CC</sub> = 5.0V ± 5% (COM'L)  | MIN. = 4.75V                              | MAX. = 5.25V  |      |       |       |
|--------------------------|---------------------------------------|--|---|---------------|------|-------|-------|
| Am2918XM                 | T <sub>A</sub> = -55°C to +125°C      | V <sub>CC</sub> = 5.0V ± 10% (MIL)   | MIN. = 4.5V                               | MAX. = 5.5V   |      |       |       |
| Parameters               | Description                           | Test Conditions (Note 1)   | Min.                                      | Typ. (Note 2) | Max. | Units |       |
| V <sub>OH</sub>          | Output HIGH Voltage                   | V <sub>CC</sub> = MIN.,<br>V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>                        | Q I <sub>OH</sub> = -1mA<br>MIL           | 2.5           | 3.4  |       | Volts |
|                          |                                       |  |   | 2.7           | 3.4  |       |       |
|                          |                                       |  | Y X <sub>M</sub> , I <sub>OH</sub> = -2mA | 2.4           | 3.4  |       |       |
|                          |                                       |  |   | 2.4           | 3.4  |       |       |
| V <sub>OL</sub>          | Output LOW Voltage (Note 6)           | V <sub>CC</sub> = MIN., I <sub>OL</sub> = 20mA<br>V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub> |   |               | 0.5  |       | Volts |
| V <sub>IH</sub>          | Input HIGH Level                      | Guaranteed input logical HIGH voltage for all inputs   | 2.0                                       |               |      |       | Volts |
| V <sub>IL</sub>          | Input LOW Level                       | Guaranteed input logical LOW voltage for all inputs  |   |               | 0.8  |       | Volts |
| V <sub>I</sub>           | Input Clamp Voltage                   | V <sub>CC</sub> = MIN., I <sub>IN</sub> = -18mA  |   |               | -1.2 |       | Volts |
| I <sub>IL</sub> (Note 3) | Input LOW Current                     | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 0.5V   |   |               | -2.0 |       | mA    |
| I <sub>IH</sub> (Note 3) | Input HIGH Current                    | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 2.7V   |   |               | 50   |       | μA    |
| I <sub>I</sub>           | Input HIGH Current                    | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 5.5V   |   |               | 1.0  |       | mA    |
| I <sub>O</sub>           | Y Output Off-State Leakage Current    | V <sub>CC</sub> = MAX.   | V <sub>O</sub> = 2.4V                     |               | 50   |       | μA    |
|                          |                                       |  | V <sub>O</sub> = 0.4V                     |               | -50  |       | μA    |
| I <sub>SC</sub>          | Output Short Circuit Current (Note 4) | V <sub>CC</sub> = MAX.   | -40                                       |               | -100 |       | mA    |
| I <sub>CC</sub>          | Power Supply Current                  | V <sub>CC</sub> = MAX. (Note 5)  |   | 80            | 130  |       | mA    |

Notes: 1. For conditions shown as MIN. or MAX., use the appropriate value specified under Electrical Characteristics for the applicable device type.

2. Typical limits are at V<sub>CC</sub> = 5.0V, T<sub>A</sub> = 25°C ambient and maximum loading.

3. Actual input currents = Unit Load Current x Input Load Factor (see Loading Rules).

4. Not more than one output should be shorted at a time. Duration of the short circuit test should not exceed one second.

5. I<sub>CC</sub> is measured with all inputs at 4.5V and all outputs open.

6. Measured on Q outputs with Y outputs open. Measured on Y outputs with Q outputs open.

## Switching Characteristics (T<sub>A</sub> = +25°C, V<sub>CC</sub> = 5.0V, R<sub>L</sub> = 280Ω)

| Parameters       | Description                |      | Test Conditions       | Min.                   | Typ. | Max. | Units |    |
|------------------|----------------------------|------|-----------------------|------------------------|------|------|-------|----|
| t <sub>PLH</sub> | Clock to Q Output          |      | C <sub>L</sub> = 15pF |                        | 6.0  | 9.0  | ns    |    |
| t <sub>PHL</sub> |                            |      |                       |                        | 8.5  | 13   |       |    |
| t <sub>pw</sub>  | Clock Pulse Width          | HIGH |                       | 7.0                    |      | ns   |       |    |
|                  |                            | LOW  |                       | 9.0                    |      |      |       |    |
| t <sub>s</sub>   | Data                       |      |                       | 5.0                    |      | ns   |       |    |
| t <sub>h</sub>   | Data                       |      |                       | 3.0                    |      | ns   |       |    |
| t <sub>PLH</sub> | Clock to Y Output (OE LOW) |      |                       |                        | 6.0  | 9.0  | ns    |    |
| t <sub>PHL</sub> |                            |      |                       |                        | 8.5  | 13   |       |    |
| t <sub>ZH</sub>  | Output Control to Output   |      |                       | C <sub>L</sub> = 15pF  |      | 12.5 | 19    | ns |
| t <sub>ZL</sub>  |                            |      |                       |                        |      | 12   | 18    |    |
| t <sub>HZ</sub>  |                            |      |                       | C <sub>L</sub> = 5.0pF |      | 4.0  | 6.0   |    |
| t <sub>LZ</sub>  |                            |      |                       |                        |      | 7.0  | 10.5  |    |
| f <sub>max</sub> | Maximum Clock Frequency    |      | C <sub>L</sub> = 15pF | 75                     | 100  |      | MHz   |    |



TRUTH TABLE

| INPUTS          |          |   | OUTPUTS |   | NOTES |
|-----------------|----------|---|---------|---|-------|
| $\overline{OE}$ | CLOCK CP | D | Q       | Y |       |
| H               | L        | X | NC      | Z | —     |
| H               | H        | X | NC      | Z | —     |
| H               | ↑        | L | L       | Z | —     |
| H               | ↑        | H | H       | Z | —     |
| L               | ↑        | L | L       | L | —     |
| L               | ↑        | H | H       | H | —     |
| L               | —        | — | L       | L | 1     |
| L               | —        | — | H       | H | 1     |

L = LOW

H = HIGH

X = Don't care

NC = No change

↑ = LOW to HIGH transition

Z = High impedance

Note: 1. When  $\overline{OE}$  is LOW, the Y output will be in the same logic state as the Q output.

LOADING RULES (In Unit Loads)

| Input/Output    | Pin No.'s | Input Unit Load | Fan-out     |            |
|-----------------|-----------|-----------------|-------------|------------|
|                 |           |                 | Output HIGH | Output LOW |
| D <sub>0</sub>  | 1         | 1               | —           | —          |
| Q <sub>0</sub>  | 2         | —               | 20          | 10*        |
| Y <sub>0</sub>  | 3         | —               | 40/130      | 10*        |
| D <sub>1</sub>  | 4         | 1               | —           | —          |
| Q <sub>1</sub>  | 5         | —               | 20          | 10*        |
| Y <sub>1</sub>  | 6         | —               | 40/130      | 10*        |
| $\overline{OE}$ | 7         | 1               | —           | —          |
| GND             | 8         | —               | —           | —          |
| CP              | 9         | 1               | —           | —          |
| Y <sub>2</sub>  | 10        | —               | 40/130      | 10*        |
| Q <sub>2</sub>  | 11        | —               | 20          | 10*        |
| D <sub>2</sub>  | 12        | 1               | —           | —          |
| Y <sub>3</sub>  | 13        | —               | 40/130      | 10*        |
| Q <sub>3</sub>  | 14        | —               | 20          | 10*        |
| D <sub>3</sub>  | 15        | 1               | —           | —          |
| V <sub>CC</sub> | 16        | —               | —           | —          |

A Schottky TTL Unit Load is defined as 50 $\mu$ A measured at 2.7V HIGH and -2.0mA measured at 0.5V LOW.

\*Fan-out on each Q<sub>i</sub> and Y<sub>i</sub> output pair should not exceed 15 unit loads (30mA) for i = 0, 1, 2, 3.

## DEFINITION OF FUNCTIONAL TERMS

**D<sub>i</sub>** The four data inputs to the register.

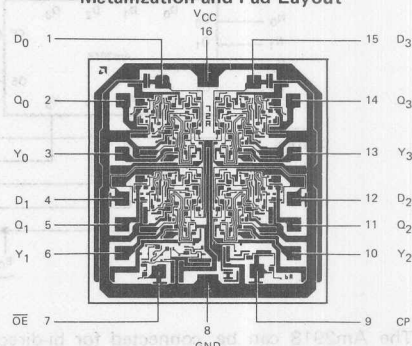
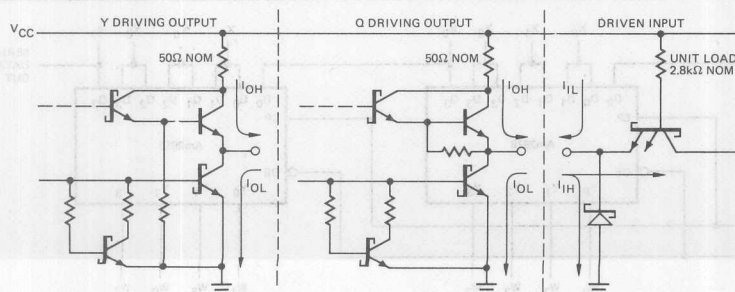
**Q<sub>i</sub>** The four data outputs of the register with standard totem-pole active pull-up outputs. Data is passed non-inverted.

**Y<sub>i</sub>** The four three-state data outputs of the register. When the three-state outputs are enabled, data is passed non-inverted. A HIGH on the "output control" input forces the Y<sub>i</sub> outputs to the high-impedance state.

**CP** Clock. The buffered common clock for the register. Enters data on the LOW-to-HIGH transition.

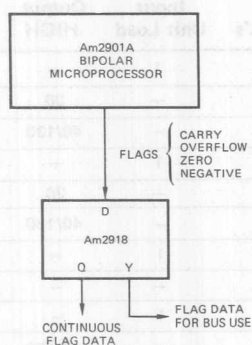
**$\overline{OE}$  Output Control.** When the  $\overline{OE}$  input is HIGH, the Y<sub>i</sub> outputs are in the high-impedance state. When the  $\overline{OE}$  input is LOW, the TRUE register data is present at the Y<sub>i</sub> outputs.

Metallization and Pad Layout

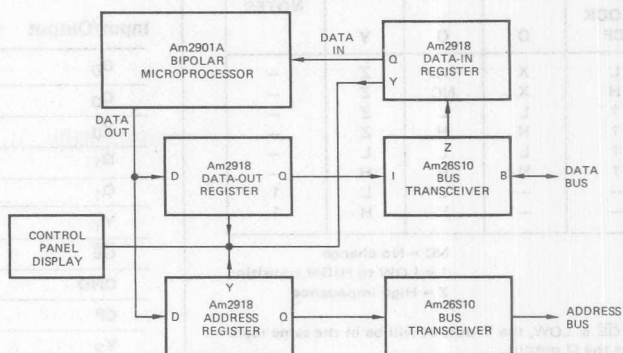
SCHOTTKY INPUT/OUTPUT  
CURRENT INTERFACE CONDITIONS

Note: Actual current flow direction shown.

## APPLICATIONS

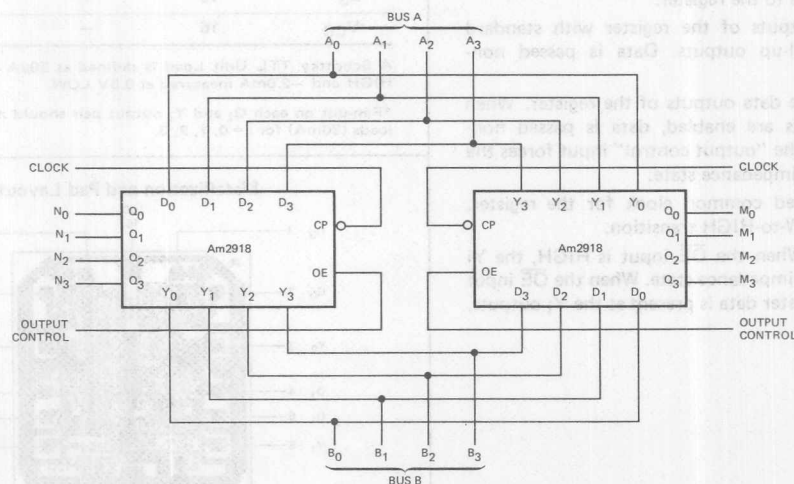


The Am2918 as a 4-bit status register



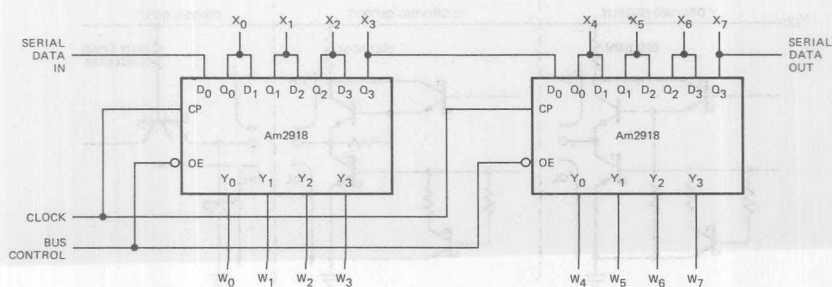
The Am2918 used as data-in, data-out and address registers.

MPR-187



The Am2918 can be connected for bi-directional interface between two buses. The device on the left stores data from the A-bus and drives the A-bus. The device on the right stores data from the B-bus and drives the A-bus. The output control is used to place either or both drivers in the high-impedance state. The contents of each register are available for continuous usage at the N and M ports of the device.

MPR-188



8-Bit serial to parallel converter with three-state output (W) and direct access to the register word (X).

MPR-189

# Am29LS18

## Quad D Register With Standard And Three-State Outputs

### DISTINCTIVE CHARACTERISTICS

- Low-power Schottky version of the popular Am2918
- Four standard totem-pole outputs
- Four three-state outputs
- Four D-type flip-flops
- 100% product assurance testing to MIL-STD-883 requirements

### FUNCTIONAL DESCRIPTION

The Am29LS18 consists of four D-type flip-flops with a buffered common clock. Information meeting the set-up and hold requirements on the D inputs is transferred to the Q outputs on the LOW-to-HIGH transition of the clock.

The same data as on the Q outputs is enabled at the three-state Y outputs when the "output control" ( $\overline{OE}$ ) input is LOW. When the  $\overline{OE}$  input is HIGH, the Y outputs are in the high-impedance state.

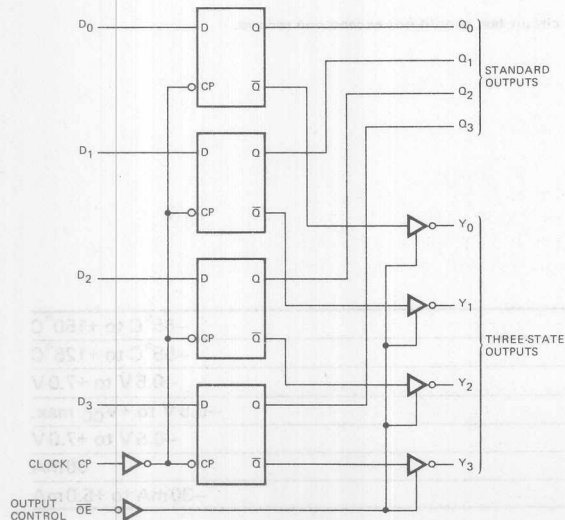
The Am29LS18 is a 4-bit, high-speed register intended for use in real-time signal processing systems where the standard outputs are used in a recursive algorithm and the three-state outputs provide access to a data bus to dump the results after a number of iterations.

The device can also be used as an address register or status register in computers or computer peripherals.

Likewise, the Am29LS18 is also useful in certain display applications where the standard outputs can be decoded to drive LED's (or equivalent) and the three-state outputs are bus organized for occasional interrogation of the data as displayed.

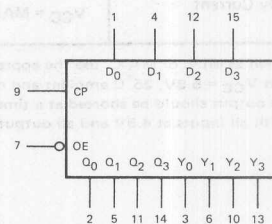
2

### LOGIC DIAGRAM



MPR-190

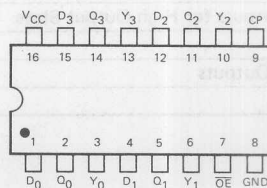
### LOGIC SYMBOL



$V_{CC}$  = Pin 16  
GND = Pin 8

MPR-191

### CONNECTION DIAGRAM Top View



Note: Pin 1 is marked for orientation.

MPR-192

# Am29LS18

## ELECTRICAL CHARACTERISTICS

The Following Conditions Apply Unless Otherwise Specified:

COM'L  $T_A = 0^\circ\text{C to } +70^\circ\text{C}$   $V_{CC} = 5.0\text{V} \pm 5\%$  (MIN. = 4.75 V MAX. = 5.25 V)  
MIL  $T_A = -55^\circ\text{C to } +125^\circ\text{C}$   $V_{CC} = 5.0\text{V} \pm 10\%$  (MIN. = 4.50 V MAX. = 5.50 V)

## DC CHARACTERISTICS OVER OPERATING RANGE

| Parameters | Description                               | Test Conditions (Note 1)                                       | Min.                           | Typ.<br>(Note 2) | Max.  | Units         |
|------------|---|--|--------------------------------|------------------|-------|---------------|
| $V_{OH}$   | Output HIGH Voltage                       | $V_{CC} = \text{MIN.}$<br>$V_{IN} = V_{IH} \text{ or } V_{IL}$ | Q, $I_{OH} = -660\mu\text{A}$  | MIL 2.5          | 3.4   | Volts         |
|            |   |  | COM'L                          | 2.7              | 3.4   |               |
|            |   | Y  | MIL, $I_{OH} = -1.0\text{mA}$  | 2.4              | 3.4   | Volts         |
|            |   |  | COM'L, $I_{OH} = 2.6\text{mA}$ | 2.4              | 3.4   |               |
| $V_{OL}$   | Output LOW Voltage                        | $V_{CC} = \text{MIN.}$<br>$V_{IN} = V_{IH} \text{ or } V_{IL}$ | $I_{OL} = 4.0\text{mA}$        |                  | 0.4   | Volts         |
|            |   |  | $I_{OL} = 8.0\text{mA}$        |                  | 0.45  |               |
|            |   |  | $I_{OL} = 12\text{mA}$         |                  | 0.5   |               |
| $V_{IH}$   | Input HIGH Level                          | Guaranteed input logical HIGH voltage for all inputs           | 2.0                            |                  |       | Volts         |
| $V_{IL}$   | Input LOW Level                           | Guaranteed input logical LOW voltage for all inputs            | MIL                            |                  | 0.7   | Volts         |
|            |   |  | COM'L                          |                  | 0.8   |               |
| $V_I$      | Input Clamp Voltage                       | $V_{CC} = \text{MIN.}$ , $I_{IN} = -18\text{mA}$               |                                |                  | -1.5  | Volts         |
| $I_{IL}$   | Input LOW Current                         | $V_{CC} = \text{MAX.}$ , $V_{IN} = 0.4\text{V}$                |                                |                  | -0.36 | mA            |
| $I_{IH}$   | Input HIGH Current                        | $V_{CC} = \text{MAX.}$ , $V_{IN} = 2.7\text{V}$                |                                |                  | 20    | $\mu\text{A}$ |
| $I_I$      | Input HIGH Current                        | $V_{CC} = \text{MAX.}$ , $V_{IN} = 7.0\text{V}$                |                                |                  | 0.1   | mA            |
| $I_O$      | Off-State (High-Impedance) Output Current | $V_{CC} = \text{MAX.}$   | $V_O = 0.4\text{V}$            |                  | -20   | $\mu\text{A}$ |
|            |   |  | $V_O = 2.4\text{V}$            |                  | 20    |               |
| $I_{SC}$   | Output Short Circuit Current (Note 3)     | $V_{CC} = \text{MAX.}$   | -15                            |                  | -85   | mA            |
| $I_{CC}$   | Power Supply Current (Note 4)             | $V_{CC} = \text{MAX.}$   |                                | 17               | 28    | mA            |

- Notes: 1. For conditions shown as MIN. or MAX., use the appropriate value specified under Electrical Characteristics for the applicable device type.  
2. Typical limits are at  $V_{CC} = 5.0\text{V}$ ,  $25^\circ\text{C}$  ambient and maximum loading.  
3. Not more than one output should be shorted at a time. Duration of the short circuit test should not exceed one second.  
4.  $I_{CC}$  is measured with all inputs at 4.5V and all outputs open.

## MAXIMUM RATINGS (Above which the useful life may be impaired)

|   |  |
|---|--|
| Storage Temperature                                 | $-65^\circ\text{C to } +150^\circ\text{C}$ |
| Temperature (Ambient) Under Bias                    | $-55^\circ\text{C to } +125^\circ\text{C}$ |
| Supply Voltage to Ground Potential Continuous       | $-0.5\text{V to } +7.0\text{V}$            |
| DC Voltage Applied to Outputs for High Output State | $-0.5\text{V to } +V_{CC} \text{ max.}$    |
| DC Input Voltage                                    | $-0.5\text{V to } +7.0\text{V}$            |
| DC Output Current, Into Outputs                     | 30mA                                       |
| DC Input Current                                    | $-30\text{mA to } +5.0\text{mA}$           |



## SWITCHING CHARACTERISTICS

(T<sub>A</sub> = +25°C, V<sub>CC</sub> = 5.0V)

| Parameters       | Description                                    |      | Min. | Typ. | Max. | Units | Test Conditions                                  |
|------------------|--|------|------|------|------|-------|--|
| t <sub>PLH</sub> | Clock to Q <sub>i</sub>                        |      |      | 18   | 27   | ns    | C <sub>L</sub> = 15pF<br>R <sub>L</sub> = 2.0kΩ  |
| t <sub>PHL</sub> |  |      |      | 18   | 27   |       |  |
| t <sub>PLH</sub> | Clock to Y <sub>i</sub> ( $\overline{OE}$ LOW) |      |      | 18   | 27   | ns    |  |
| t <sub>PHL</sub> |  |      |      | 18   | 27   |       |  |
| t <sub>pw</sub>  | Clock Pulse Width                              | LOW  | 18   |      | ns   |       |  |
|                  |  | HIGH | 15   |      |      |       |  |
| t <sub>s</sub>   | Data   |      | 15   |      | ns   |       |  |
| t <sub>h</sub>   | Data   |      | 5.0  |      | ns   |       |  |
| t <sub>ZH</sub>  | $\overline{OE}$ to Y <sub>i</sub>              |      |      | 7.0  | 11   | ns    |  |
| t <sub>ZL</sub>  |  |      |      | 8    | 12   |       |  |
| t <sub>HZ</sub>  | $\overline{OE}$ to Y <sub>i</sub>              |      |      | 14   | 21   | ns    | C <sub>L</sub> = 5.0pF<br>R <sub>L</sub> = 2.0kΩ |
| t <sub>LZ</sub>  |  |      |      | 12   | 18   |       |  |
| f <sub>max</sub> | Maximum Clock Frequency (Note 1)               |      | 35   | 50   |      | MHz   |  |

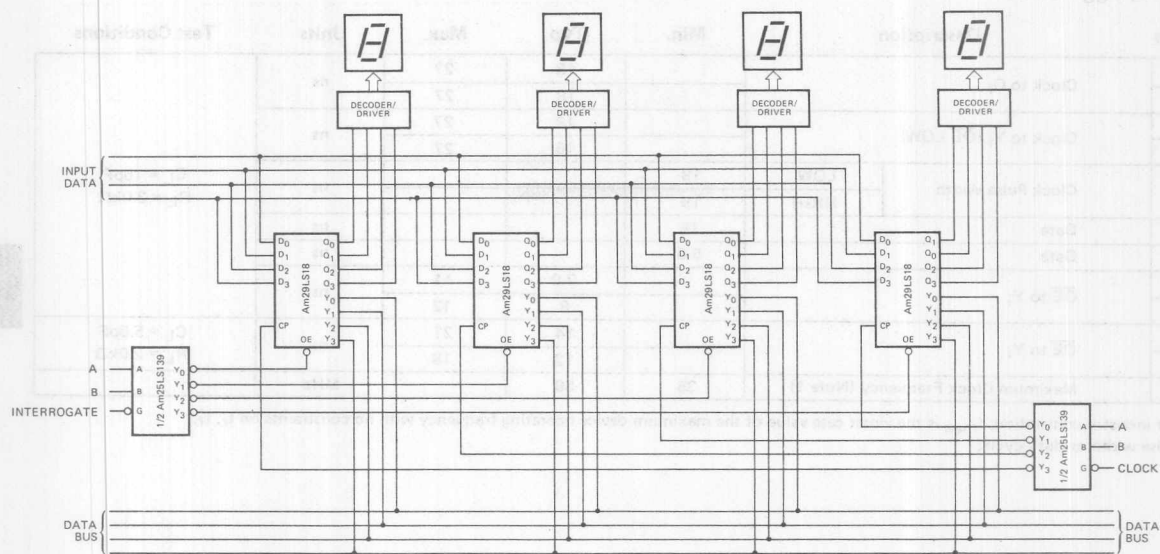
Note 1. Per industry convention, f<sub>max</sub> is the worst case value of the maximum device operating frequency with no constraints on t<sub>r</sub>, t<sub>f</sub>, pulse width or duty cycle.

SWITCHING CHARACTERISTICS  
OVER OPERATING RANGE\*

| SWITCHING CHARACTERISTICS<br>OVER OPERATING RANGE* |  | Am29LS18PC, DC  |      | Am29LS18DM, FM   |      | Units | Test Conditions                                  |
|--|--|---|------|--|------|-------|--|
|  |  | T <sub>A</sub> = 0°C to +70°C<br>V <sub>CC</sub> = 5.0V ±5% |      | T <sub>A</sub> = -55°C to +125°C<br>V <sub>CC</sub> = 5.0V ± 10% |      |       |  |
|  |  | Min.  | Max. | Min.   | Max. |       |  |
| Parameters   | Description                                    |   |      |  |      |       |  |
| t <sub>PLH</sub>                                   | Clock to Q <sub>i</sub>                        |   | 38   |  | 45   | ns    | C <sub>L</sub> = 50pF<br>R <sub>L</sub> = 2.0kΩ  |
| t <sub>PHL</sub>                                   |  |   | 38   |  | 45   |       |  |
| t <sub>PLH</sub>                                   | Clock to Y <sub>i</sub> ( $\overline{OE}$ LOW) |   | 35   |  | 40   | ns    |  |
| t <sub>PHL</sub>                                   |  |   | 35   |  | 40   |       |  |
| t <sub>pw</sub>                                    | Clock Pulse Width                              | LOW   | 20   | 20   | ns   |       |  |
|  |  | HIGH  | 20   | 20   |      |       |  |
| t <sub>s</sub>                                     | Data   | 15  | 15   | 15   | ns   |       |  |
| t <sub>h</sub>                                     | Data   | 5.0   | 5.0  | 5.0  | ns   |       |  |
| t <sub>ZH</sub>                                    | $\overline{OE}$ to Y <sub>i</sub>              |   | 15   |  | 17   | ns    |  |
| t <sub>ZL</sub>                                    |  |   | 16   |  | 17   |       |  |
| t <sub>HZ</sub>                                    | $\overline{OE}$ to Y <sub>i</sub>              |   | 27   |  | 30   | ns    | C <sub>L</sub> = 5.0pF<br>R <sub>L</sub> = 2.0kΩ |
| t <sub>LZ</sub>                                    |  |   | 24   |  | 30   |       |  |
| f <sub>max</sub>                                   | Maximum Clock Frequency (Note 1)               | 30  |      |  |      | MHz   |  |

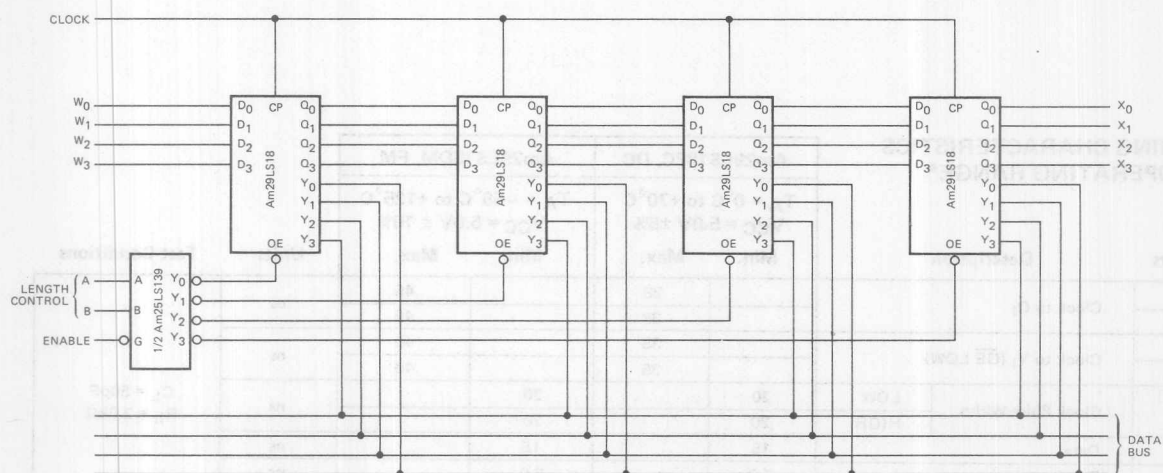
\*AC performance over the operating temperature range is guaranteed by testing defined in Group A, Subgroup 9.

## APPLICATIONS



The Am29LS18 used as a display register with bus interrogate capability.

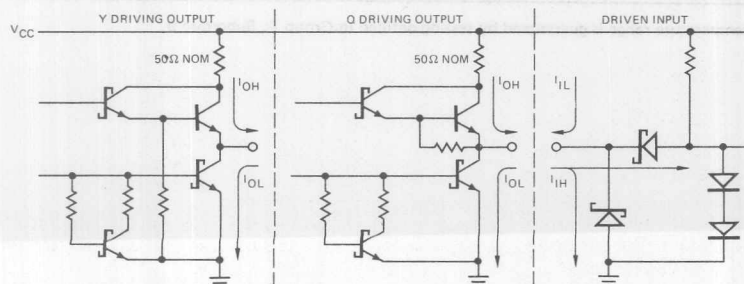
MPR-193



The Am29LS18 as a variable length (1, 2, 3 or 4 word) shift register.

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### LOW-POWER SCHOTTKY INPUT/OUTPUT CURRENT INTERFACE CONDITIONS



Note: Actual current flow direction shown.

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## DEFINITION OF FUNCTIONAL TERMS

**D<sub>i</sub>** The four data inputs to the register.

**Q<sub>i</sub>** The four data outputs of the register with standard totem-pole active pull-up outputs. Data is passed non-inverted.

**Y<sub>i</sub>** The four three-state data outputs of the register. When the three-state outputs are enabled, data is passed non-inverted. A HIGH on the "output control" input forces the Y<sub>i</sub> outputs to the high-impedance state.

**CP** Clock. The buffered common clock for the register. Enters data on the LOW-to-HIGH transition.

**OE** Output Control. When the OE input is HIGH, the Y<sub>i</sub> outputs are in the high-impedance state. When the OE input is LOW, the TRUE register data is present at the Y<sub>i</sub> outputs.

## TRUTH TABLE

| INPUTS |          |   | OUTPUTS |   | NOTES |
|--------|----------|---|---------|---|-------|
| OE     | CLOCK CP | D | Q       | Y |       |
| H      | L        | X | NC      | Z | —     |
| H      | H        | X | NC      | Z | —     |
| H      | ↑        | L | L       | Z | —     |
| H      | ↑        | H | H       | Z | —     |
| L      | ↑        | L | L       | L | —     |
| L      | ↑        | H | H       | H | —     |
| L      | —        | — | L       | L | 1     |
| L      | —        | — | H       | H | 1     |

L = LOW

H = HIGH

X = Don't care

NC = No change

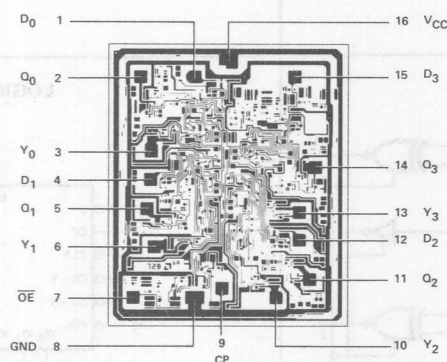
↑ = LOW to HIGH transition

Z = High impedance

Note: 1. When OE is LOW, the Y output will be in the same logic state as the Q output.

2

## Metallization and Pad Layout



DIE SIZE 0.083" x 0.099"

## ORDERING INFORMATION

Order the part number according to the table below to obtain the desired package, temperature range, and screening level.

| Order Number | Package Type<br>(Note 1) | Operating Range<br>(Note 2) | Screening Level<br>(Note 3)                          |
|--------------|--------------------------|-----------------------------|--|
| AM29LS18PC   | P-16                     | C                           | C-1  |
| AM29LS18DC   | D-16                     | C                           | C-1  |
| AM29LS18DC-B | D-16                     | C                           | B-1  |
| AM29LS18DM   | D-16                     | M                           | C-3  |
| AM29LS18DM-B | D-16                     | M                           | B-3  |
| AM29LS18FM   | F-16                     | M                           | C-3  |
| AM29LS18FM-B | F-16                     | M                           | B-3  |
| AM29LS18XC   | Dice                     | C                           | Visual inspection<br>to MIL-STD-883<br>Method 2010B. |
| AM29LS18XM   | Dice                     | M                           |  |

Notes: 1. P = Molded DIP, D = Hermetic DIP, F = Flat Pak. Number following letter is number of leads. See Appendix B for detailed outline.

Where Appendix B contains several dash numbers, any of the variations of the package may be used unless otherwise specified.

2. C = 0°C to +70°C, V<sub>CC</sub> = 4.75V to 5.25V, M = -55°C to +125°C, V<sub>CC</sub> = 4.50V to 5.50V.

3. See Appendix A for details of screening. Levels C-1 and C-3 conform to MIL-STD-883, Class C. Level B-3 conforms to MIL-STD-883, Class B.

# Am2919

## Quad Register With Dual Three-State Outputs

### DISTINCTIVE CHARACTERISTICS

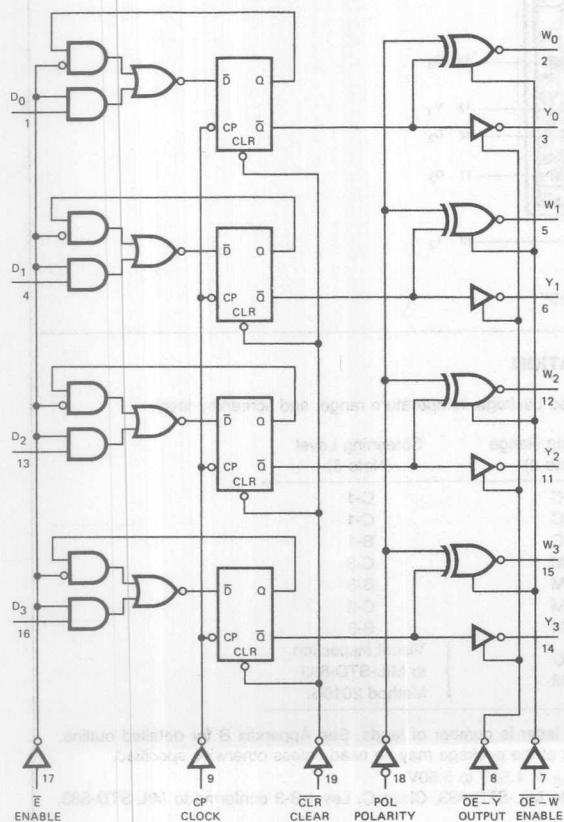
- Two sets of three-state outputs
- Four D-type flip-flops
- Polarity control on one set of outputs
- Buffered common clock enable
- Buffered common asynchronous clear
- Separate buffered common output enable for each set of outputs
- 100% reliability assurance testing in compliance with MIL STD-883

### FUNCTIONAL DESCRIPTION

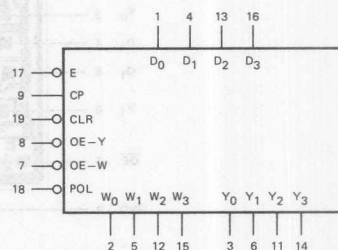
The Am2919 consists of four D-type flip-flops with a buffered common clock enable. Information meeting the set-up and hold time requirements of the D inputs is transferred to the flip-flop outputs on the LOW-to-HIGH transition of the clock. Data on the Q outputs of the flip-flops is enabled at the three-state outputs when the output control ( $\overline{OE}$ ) input is LOW. When the appropriate  $\overline{OE}$  input is HIGH, the outputs are in the high impedance state. Two independent sets of outputs—W and Y—are provided such that the register can simultaneously and independently drive two buses. One set of outputs contains a polarity control such that the outputs can either be inverting or non-inverting.

The device also features an active LOW asynchronous clear. When the clear input is LOW, the Q output of the internal flip-flops are forced LOW independent of the other inputs. The Am2919 is packaged in a space-saving (0.3-inch row spacing) 20-pin package.

### LOGIC DIAGRAM



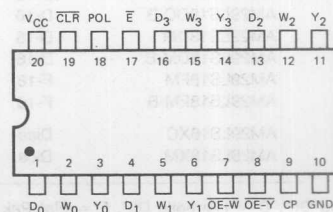
### LOGIC SYMBOL



$V_{CC}$  = Pin 20  
GND = Pin 10

MPR-197

### CONNECTION DIAGRAM Top View



Note: Pin 1 is marked for orientation.

MPR-198



**ELECTRICAL CHARACTERISTICS**

The Following Conditions Apply Unless Otherwise Specified:

COM'L  $T_A = 0^\circ\text{C to } +70^\circ\text{C}$   $V_{CC} = 5.0\text{V} \pm 5\%$  MIN. = 4.75 V MAX. = 5.25 V  
 MIL  $T_A = -55^\circ\text{C to } +125^\circ\text{C}$   $V_{CC} = 5.0\text{V} \pm 10\%$  MIN. = 4.50 V MAX. = 5.50 V

**DC CHARACTERISTICS OVER OPERATING RANGE**

| Parameters | Description                               | Test Conditions (Note 1)                                       |                                 | Min. | Typ.<br>(Note 2) | Max.  | Units         |
|------------|---|--|---------------------------------|------|------------------|-------|---------------|
| $V_{OH}$   | Output HIGH Voltage                       | $V_{CC} = \text{MIN.}$<br>$V_{IN} = V_{IH} \text{ or } V_{IL}$ | MIL, $I_{OH} = -1.0\text{mA}$   | 2.4  | 3.4              |       | Volts         |
|            |   |  | COM'L, $I_{OH} = -2.6\text{mA}$ | 2.4  | 3.4              |       |               |
| $V_{OL}$   | Output LOW Voltage                        | $V_{CC} = \text{MIN.}$<br>$V_{IN} = V_{IH} \text{ or } V_{IL}$ | $I_{OL} = 4.0\text{mA}$         |      |                  | 0.4   | Volts         |
|            |   |  | $I_{OL} = 8.0\text{mA}$         |      |                  | 0.45  |               |
|            |   |  | $I_{OL} = 12\text{mA}$          |      |                  | 0.5   |               |
| $V_{IH}$   | Input HIGH Level                          | Guaranteed input logical HIGH voltage for all inputs           |                                 | 2.0  |                  |       | Volts         |
| $V_{IL}$   | Input LOW Level                           | Guaranteed input logical LOW voltage for all inputs            | MIL                             |      |                  | 0.7   | Volts         |
|            |   |  | COM'L                           |      |                  | 0.8   |               |
| $V_I$      | Input Clamp Voltage                       | $V_{CC} = \text{MIN.}, I_{IN} = -18\text{mA}$                  |                                 |      |                  | -1.5  | Volts         |
| $I_{IL}$   | Input LOW Current                         | $V_{CC} = \text{MAX.}, V_{IN} = 0.4\text{V}$                   |                                 |      |                  | -0.36 | mA            |
| $I_{IH}$   | Input HIGH Current                        | $V_{CC} = \text{MAX.}, V_{IN} = 2.7\text{V}$                   |                                 |      |                  | 20    | $\mu\text{A}$ |
| $I_I$      | Input HIGH Current                        | $V_{CC} = \text{MAX.}, V_{IN} = 7.0\text{V}$                   |                                 |      |                  | 0.1   | mA            |
| $I_O$      | Off-State (High-Impedance) Output Current | $V_{CC} = \text{MAX.}$   | $V_O = 0.4\text{V}$             |      |                  | -20   | $\mu\text{A}$ |
|            |   |  | $V_O = 2.4\text{V}$             |      |                  | 20    |               |
| $I_{SC}$   | Output Short Circuit Current (Note 3)     | $V_{CC} = \text{MAX.}$   |                                 | -15  |                  | -85   | mA            |
| $I_{CC}$   | Power Supply Current (Note 4)             | $V_{CC} = \text{MAX.}$   | MIL                             |      | 24               | 36    | mA            |
|            |   |  | COM'L                           |      | 24               | 39    |               |

Notes: 1. For conditions shown as MIN. or MAX., use the appropriate value specified under Electrical Characteristics for the applicable device type.

2. Typical limits are at  $V_{CC} = 5.0\text{V}$ ,  $25^\circ\text{C}$  ambient and maximum loading.

3. Not more than one output should be shorted at a time. Duration of the short circuit test should not exceed one second.

4. Inputs grounded; outputs open.

**MAXIMUM RATINGS** (Above which the useful life may be impaired)

|   |  |
|---|--|
| Storage Temperature                                 | $-65^\circ\text{C to } +150^\circ\text{C}$ |
| Temperature (Ambient) Under Bias                    | $-55^\circ\text{C to } +125^\circ\text{C}$ |
| Supply Voltage to Ground Potential Continuous       | $-0.5\text{V to } +7.0\text{V}$            |
| DC Voltage Applied to Outputs for High Output State | $-0.5\text{V to } +V_{CC} \text{ max.}$    |
| DC Input Voltage                                    | $-0.5\text{V to } +7.0\text{V}$            |
| DC Output Current, Into Outputs                     | 30 mA                                      |
| DC Input Current                                    | $-30\text{mA to } +5.0\text{mA}$           |

**FUNCTION TABLE**

| FUNCTION                   | INPUTS     |       |           |     |     |                     |                     | INTERNAL | OUTPUTS       |               |
|----------------------------|------------|-------|-----------|-----|-----|---------------------|---------------------|----------|---------------|---------------|
|                            | CP         | $D_i$ | $\bar{E}$ | CLR | POL | $\bar{OE}\text{-W}$ | $\bar{OE}\text{-Y}$ | Q        | $W_i$         | $Y_i$         |
| Output Three-State Control | X          | X     | X         | X   | X   | H                   | L                   | NC       | Z             | Enabled       |
|                            | X          | X     | X         | X   | X   | L                   | H                   | NC       | Z             | Enabled       |
|                            | X          | X     | X         | X   | X   | H                   | H                   | NC       | Z             | Z             |
|                            | X          | X     | X         | X   | X   | L                   | L                   | NC       | Enabled       | Enabled       |
| $W_i$ Polarity             | X          | X     | X         | X   | L   | L                   | L                   | NC       | Non-Inverting | Non-Inverting |
|                            | X          | X     | X         | X   | H   | L                   | L                   | NC       | Inverting     | Non-Inverting |
| Asynchronous Clear         | X          | X     | X         | L   | L   | L                   | L                   | L        | L             | L             |
|                            | X          | X     | X         | L   | H   | L                   | L                   | L        | H             | L             |
| Clock Enabled              | $\uparrow$ | X     | H         | H   | X   | X                   | X                   | NC       | NC            | NC            |
|                            | $\uparrow$ | L     | L         | H   | L   | L                   | L                   | L        | L             | L             |
|                            | $\uparrow$ | L     | L         | H   | H   | L                   | L                   | L        | H             | L             |
|                            | $\uparrow$ | H     | L         | H   | L   | L                   | L                   | H        | H             | H             |
|                            | $\uparrow$ | H     | L         | H   | H   | L                   | L                   | H        | L             | H             |

L = LOW H = HIGH Z = High Impedance NC = No Change X = Don't Care  $\uparrow$  = LOW-to-HIGH Transition

## Am2919

## SWITCHING CHARACTERISTICS

(T<sub>A</sub> = +25°C, V<sub>CC</sub> = 5.0V)

| Parameters       | Description  |      | Min. | Typ. | Max. | Units | Test Conditions                                 |
|------------------|--|------|------|------|------|-------|---|
| t <sub>PHL</sub> | Clock to Y <sub>i</sub>                            |      |      | 22   | 33   | ns    | C <sub>L</sub> = 15pF<br>R <sub>L</sub> = 2.0kΩ |
| t <sub>PHL</sub> |  |      |      | 20   | 30   |       |   |
| t <sub>PLH</sub> | Clock to W <sub>i</sub><br>(Either Polarity)       |      |      | 24   | 36   | ns    |   |
| t <sub>PHL</sub> |  |      |      | 24   | 36   |       |   |
| t <sub>PHL</sub> | Clear to Y <sub>i</sub>                            |      |      | 29   | 43   | ns    |   |
| t <sub>PLH</sub> | Clear to W <sub>i</sub>                            |      |      | 25   | 37   | ns    |   |
| t <sub>PHL</sub> |  |      |      | 30   | 45   |       |   |
| t <sub>PLH</sub> | Polarity to W <sub>i</sub>                         |      |      | 23   | 34   | ns    |   |
| t <sub>PHL</sub> |  |      |      | 25   | 37   |       |   |
| t <sub>pw</sub>  | Clear  |      | 18   |      |      | ns    |   |
| t <sub>pw</sub>  | ClockPulse Width                                   | LOW  | 15   |      |      | ns    |   |
|                  |  | HIGH | 18   |      |      |       |   |
| t <sub>s</sub>   | Data   |      | 15   |      |      | ns    |   |
| t <sub>h</sub>   | Data   |      | 5    |      |      | ns    |   |
| t <sub>s</sub>   | Data Enable  |      | 20   |      |      | ns    |   |
| t <sub>h</sub>   | Data Enable  |      | 0    |      |      | ns    |   |
| t <sub>s</sub>   | Set-up Time, Clear<br>Recovery (Inactive) to Clock |      | 20   | 15   |      | ns    |   |
| t <sub>ZH</sub>  | Output Enable to W or Y                            |      |      | 11   | 17   | ns    |   |
| t <sub>ZL</sub>  |  |      |      | 13   | 20   |       |   |
| t <sub>HZ</sub>  | Output Enable to W or Y                            |      |      | 13   | 20   | ns    |   |
| t <sub>LZ</sub>  |  |      |      | 11   | 17   |       |   |
| f <sub>max</sub> | Maximum Clock Frequency (Note 1)                   |      | 35   | 45   |      | MHz   |   |

Note 1. Per industry convention, f<sub>max</sub> is the worst case value of the maximum device operating frequency with no constraints on t<sub>r</sub>, t<sub>f</sub>, pulse width or duty cycle.

SWITCHING CHARACTERISTICS  
OVER OPERATING RANGE\*

| Parameters       | Description  |      | Min. | Max. | Min. | Max. | Units | Test Conditions                                 |
|------------------|--|------|------|------|------|------|-------|---|
| t <sub>PLH</sub> | Clock to Y <sub>i</sub>                            |      |      | 39   |      | 42   | ns    | C <sub>L</sub> = 50pF<br>R <sub>L</sub> = 2.0kΩ |
| t <sub>PHL</sub> |  |      |      | 39   |      | 45   |       |   |
| t <sub>PLH</sub> | Clock to W <sub>i</sub><br>(Either Polarity)       |      |      | 41   |      | 43   | ns    |   |
| t <sub>PHL</sub> |  |      |      | 44   |      | 48   |       |   |
| t <sub>PHL</sub> | Clear to Y <sub>i</sub>                            |      |      | 52   |      | 58   | ns    |   |
| t <sub>PLH</sub> | Clear to W <sub>i</sub>                            |      |      | 42   |      | 43   | ns    |   |
| t <sub>PHL</sub> |  |      |      | 51   |      | 53   |       |   |
| t <sub>PLH</sub> | Polarity to W <sub>i</sub>                         |      |      | 41   |      | 45   | ns    |   |
| t <sub>PHL</sub> |  |      |      | 42   |      | 44   |       |   |
| t <sub>pw</sub>  | Clear  |      | 20   |      | 20   |      | ns    |   |
| t <sub>pw</sub>  | Clock  | LOW  | 20   |      | 20   |      | ns    |   |
|                  |  | HIGH | 20   |      | 20   |      |       |   |
| t <sub>s</sub>   | Data   |      | 15   |      | 15   |      | ns    |   |
| t <sub>h</sub>   | Data   |      | 10   |      | 10   |      | ns    |   |
| t <sub>s</sub>   | Data Enable  |      | 25   |      | 25   |      | ns    |   |
| t <sub>h</sub>   | Data Enable  |      | 0    |      | 0    |      | ns    |   |
| t <sub>s</sub>   | Set-up Time, Clear<br>Recovery (Inactive) to Clock |      | 23   |      | 24   |      | ns    |   |
| t <sub>ZH</sub>  | Output Enable to W <sub>i</sub> or Y <sub>i</sub>  |      |      | 24   |      | 27   | ns    |   |
| t <sub>ZL</sub>  |  |      |      | 29   |      | 35   |       |   |
| t <sub>HZ</sub>  | Output Enable to W <sub>i</sub> or Y <sub>i</sub>  |      |      | 33   |      | 45   | ns    |   |
| t <sub>LZ</sub>  |  |      |      | 22   |      | 26   |       |   |
| f <sub>max</sub> | Maximum Clock Frequency (Note 1)                   |      | 30   |      | 25   |      | MHz   | C <sub>L</sub> = 50pF<br>R <sub>L</sub> = 2.0kΩ |

\* AC performance over the operating temperature range is guaranteed by testing defined in Group A, Subgroup 9.

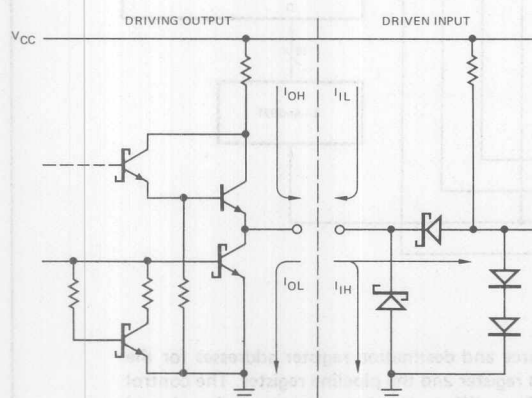
## DEFINITION OF FUNCTIONAL TERMS

|                                    |  |
|------------------------------------|--|
| $D_i$                              | Any of the four D flip-flop data lines.  |
| $\bar{E}$                          | Clock Enable. When LOW, the data is entered into the register on the next clock LOW-to-HIGH transition. When HIGH, the data in the register remains unchanged, regardless of the data in.  |
| CP                                 | Clock Pulse. Data is entered into the register on the LOW-to-HIGH transition.  |
| $\overline{OE-W}, \overline{OE-Y}$ | Output Enable. When $\overline{OE}$ is LOW, the register is enable to the output. When HIGH, the output is in the high-impedance state. The $\overline{OE-W}$ controls the W set of outputs, and $\overline{OE-Y}$ controls the Y set. |
| $Y_i$                              | Any of the four non-inverting three-state output lines.  |
| $W_i$                              | Any of the four three-state outputs with polarity control.   |
| POL                                | Polarity Control. The $W_i$ outputs will be non-inverting when POL is LOW, and when it is HIGH, the outputs are inverting.   |
| $\overline{CLR}$                   | Asynchronous Clear. When $\overline{CLR}$ is LOW, the internal Q flip-flops are reset to LOW.  |

GUARANTEED LOADING RULES  
OVER OPERATING RANGE (In Unit Loads)

A Low-Power Schottky TTL Unit Load is defined as  $20\mu A$  measured at 2.7V HIGH and  $-0.36mA$  measured at 0.4V LOW.

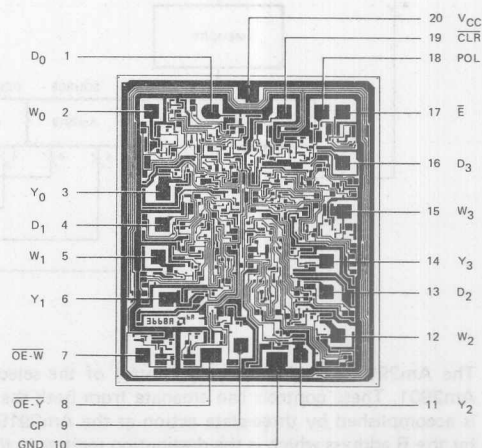
| Pin No.'s | Input/Output      | Input Load | Output HIGH |       | Output LOW |       |
|-----------|-------------------|------------|-------------|-------|------------|-------|
|           |                   |            | MIL         | COM'L | MIL        | COM'L |
| 1         | $D_0$             | 1.0        | —           | —     | —          | —     |
| 2         | $W_0$             | —          | 50          | 130   | 33         | 33    |
| 3         | $Y_0$             | —          | 50          | 130   | 33         | 33    |
| 4         | $D_1$             | 1.0        | —           | —     | —          | —     |
| 5         | $W_1$             | —          | 50          | 130   | 33         | 33    |
| 6         | $Y_1$             | —          | 50          | 130   | 33         | 33    |
| 7         | $\overline{OE-W}$ | 1.0        | —           | —     | —          | —     |
| 8         | $\overline{OE-Y}$ | 1.0        | —           | —     | —          | —     |
| 9         | CP                | 1.0        | —           | —     | —          | —     |
| 10        | GND               | —          | —           | —     | —          | —     |
| 11        | $Y_2$             | —          | 50          | 130   | 33         | 33    |
| 12        | $W_2$             | —          | 50          | 130   | 33         | 33    |
| 13        | $D_2$             | 1.0        | —           | —     | —          | —     |
| 14        | $Y_3$             | —          | 50          | 130   | 33         | 33    |
| 15        | $W_3$             | —          | 50          | 130   | 33         | 33    |
| 16        | $D_3$             | 1.0        | —           | —     | —          | —     |
| 17        | $\bar{E}$         | 1.0        | —           | —     | —          | —     |
| 18        | POL               | 1.0        | —           | —     | —          | —     |
| 19        | $\overline{CLR}$  | 1.0        | —           | —     | —          | —     |
| 20        | $V_{CC}$          | —          | —           | —     | —          | —     |

LOW-POWER SCHOTTKY INPUT/OUTPUT  
CURRENT INTERFACE CONDITIONS

Note: Actual current flow direction shown.

MPR-199

## Metallization and Pad Layout



DIE SIZE 0.083" X 0.099"

## ORDERING INFORMATION

Order the part number according to the table below to obtain the desired package, temperature range, and screening level.

| Order Number | Package Type<br>(Note 1) | Operating Range<br>(Note 2) | Screening Level<br>(Note 3)                          |
|--------------|--------------------------|-----------------------------|--|
| AM2919PC     | P-20                     | C                           | C-1  |
| AM2919DC     | D-20                     | C                           | C-1  |
| AM2919DC-B   | D-20                     | C                           | B-1  |
| AM2919DM     | D-20                     | M                           | C-3  |
| AM2919DM-B   | D-20                     | M                           | B-3  |
| AM2919FM     | F-20                     | M                           | C-3  |
| AM2919FM-B   | F-20                     | M                           | B-3  |
| AM2919XC     | Dice                     | C                           | Visual inspection<br>to MIL-STD-883<br>Method 2010B. |
| AM2919XM     | Dice                     | M                           |  |

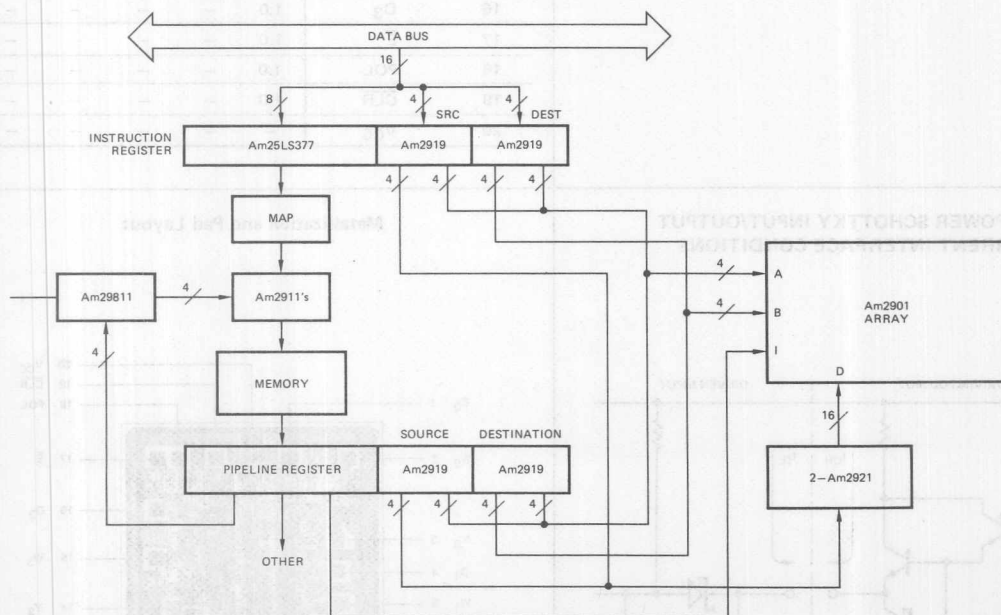
Notes: 1. P = Molded DIP, D = Hermetic DIP, F = Flat Pak. Number following letter is number of leads. See Appendix B for detailed outline.

Where Appendix B contains several dash numbers, any of the variations of the package may be used unless otherwise specified.

2.  $C = 0^{\circ}\text{C}$  to  $+70^{\circ}\text{C}$ ,  $V_{CC} = 4.75\text{V}$  to  $5.25\text{V}$ ,  $M = -55^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ ,  $V_{CC} = 4.50\text{V}$  to  $5.50\text{V}$ .

3. See Appendix A for details of screening. Levels C-1 and C-3 conform to MIL-STD-883, Class B.

## APPLICATION



The Am2919 provides for easy control of the selection of source and destination register addresses for the Am2901. These controls can emanate from both the instruction register and the pipeline register. The control is accomplished by three-state action at the Am2919 outputs. Four different register outputs can be selected by the B address which is the destination register in the Am2901. Two registers can be selected for the Am2901 A input which is a second RAM source.

The other pair of three-state outputs can be used for function control select as shown with the Am2921. Here, bit set, bit clear, bit toggle and bit test on any of the 16 bits can be performed.



# Am2920

## Octal D-Type Flip-Flop With Clear, Clock Enable And Three-State Control

### DISTINCTIVE CHARACTERISTICS

- Buffered common clock enable input
- Buffered common asynchronous clear input
- Three-state outputs
- 8-bit, high-speed parallel register with positive edge-triggered, D-type flip-flops
- 100% reliability assurance testing in compliance with MIL-STD-883

### FUNCTIONAL DESCRIPTION

The Am2920 is an 8-bit register built using advanced Low-Power Schottky technology. The register consists of eight D-type flip-flops with a buffered common clock, a buffered common clock enable, a buffered asynchronous clear input, and three-state outputs.

When the clear input is LOW, the internal flip-flops of the register are reset to logic 0 (LOW), independent of all other inputs. When the clear input is HIGH, the register operates in the normal fashion.

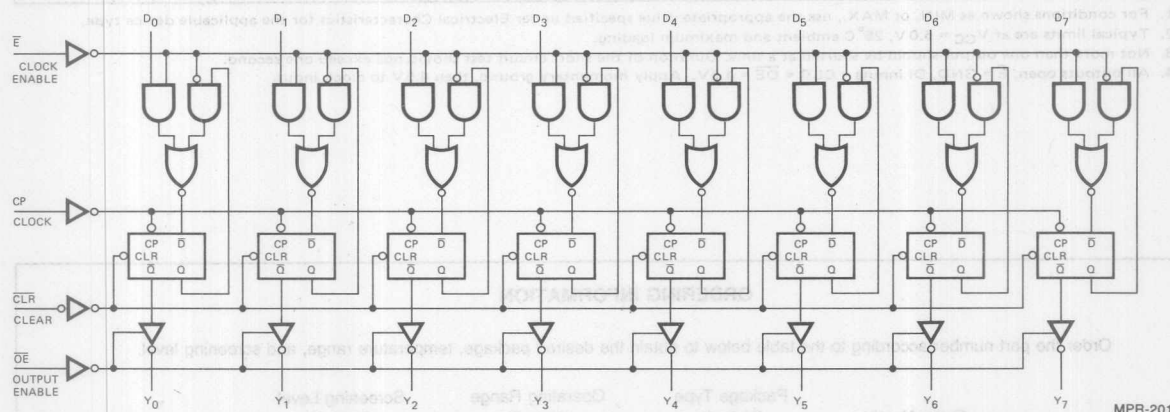
When the three-state output enable ( $\overline{OE}$ ) input is LOW, the Y outputs are enabled and appear as normal TTL outputs. When the output enable ( $\overline{OE}$ ) input is HIGH, the Y outputs are in the high impedance (three-state) condition. This does not affect the internal state of the flip-flop Q output.

The clock enable input ( $\overline{E}$ ) is used to selectively load data into the register. When the  $\overline{E}$  input is HIGH, the register will retain its current data. When the  $\overline{E}$  is LOW, new data is entered into the register on the LOW-to-HIGH transition of the clock input.

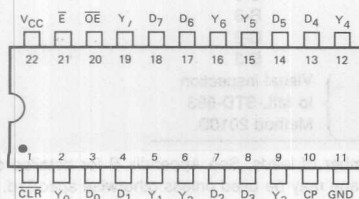
This device is packaged in a space-saving (0.4-inch row spacing) 22-pin package.

2

### LOGIC DIAGRAM



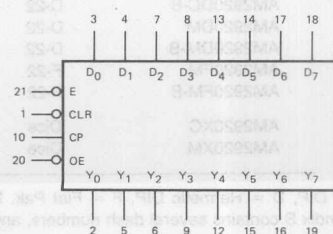
### CONNECTION DIAGRAM Top View



Note: Pin 1 is marked for orientation.

MPR-202

### LOGIC SYMBOL



VCC = Pin 22  
GND = Pin 11

MPR-203

# Am2920

## ELECTRICAL CHARACTERISTICS

The Following Conditions Apply Unless Otherwise Specified:

COM'L  $T_A = 0^\circ\text{C to } +70^\circ\text{C}$   $V_{CC} = 5.0\text{V} \pm 5\%$  MIN. = 4.75V MAX. = 5.25V  
MIL  $T_A = -55^\circ\text{C to } +125^\circ\text{C}$   $V_{CC} = 5.0\text{V} \pm 10\%$  MIN. = 4.50V MAX. = 5.50V

## DC CHARACTERISTICS OVER OPERATING RANGE

| Parameters | Description                               | Test Conditions (Note 1)                                       | Min.                            | Typ.<br>(Note 2) | Max.  | Units         |
|------------|---|--|---------------------------------|------------------|-------|---------------|
| $V_{OH}$   | Output HIGH Voltage                       | $V_{CC} = \text{MIN.}$<br>$V_{IN} = V_{IH} \text{ or } V_{IL}$ | MIL, $I_{OH} = -1.0\text{mA}$   | 2.4              | 3.4   | Volts         |
|            |   |  | COM'L, $I_{OH} = -2.6\text{mA}$ | 2.4              | 3.4   |               |
| $V_{OL}$   | Output LOW Voltage                        | $V_{CC} = \text{MIN.}$<br>$V_{IN} = V_{IH} \text{ or } V_{IL}$ | $I_{OL} = 4.0\text{mA}$         |                  | 0.4   | Volts         |
|            |   |  | $I_{OL} = 8.0\text{mA}$         |                  | 0.45  |               |
| $V_{IH}$   | Input HIGH Level                          | Guaranteed input logical HIGH voltage for all inputs           |                                 | 2.0              |       | Volts         |
| $V_{IL}$   | Input LOW Level                           | Guaranteed input logical LOW voltage for all inputs            | MIL                             |                  | 0.7   | Volts         |
|            |   |  | COM'L                           |                  | 0.8   |               |
| $V_I$      | Input Clamp Voltage                       | $V_{CC} = \text{MIN.}$ , $I_{IN} = -18\text{mA}$               |                                 |                  | -1.5  | Volts         |
| $I_{IL}$   | Input LOW Current                         | $V_{CC} = \text{MAX.}$ , $V_{IN} = 0.4\text{V}$                |                                 |                  | -0.36 | mA            |
| $I_{IH}$   | Input HIGH Current                        | $V_{CC} = \text{MAX.}$ , $V_{IN} = 2.7\text{V}$                |                                 |                  | 20    | $\mu\text{A}$ |
| $I_I$      | Input HIGH Current                        | $V_{CC} = \text{MAX.}$ , $V_{IN} = 7.0\text{V}$                |                                 |                  | 0.1   | mA            |
| $I_O$      | Off-State (High-Impedance) Output Current | $V_{CC} = \text{MAX.}$   | $V_O = 0.4\text{V}$             |                  | -20   | $\mu\text{A}$ |
|            |   |  | $V_O = 2.4\text{V}$             |                  | 20    |               |
| $I_{SC}$   | Output Short Circuit Current (Note 3)     | $V_{CC} = \text{MAX.}$   |                                 | -15              | -85   | mA            |
| $I_{CC}$   | Power Supply Current (Note 4)             | $V_{CC} = \text{MAX.}$   |                                 | 24               | 37    | mA            |

- Notes: 1. For conditions shown as MIN. or MAX., use the appropriate value specified under Electrical Characteristics for the applicable device type.  
2. Typical limits are at  $V_{CC} = 5.0\text{V}$ ,  $25^\circ\text{C}$  ambient and maximum loading.  
3. Not more than one output should be shorted at a time. Duration of the short circuit test should not exceed one second.  
4. All outputs open,  $\bar{E} = \text{GND}$ , Di inputs =  $\text{CLR} = \text{OE} = 4.5\text{V}$ . Apply momentary ground, then 4.5V to clock input.

## ORDERING INFORMATION

Order the part number according to the table below to obtain the desired package, temperature range, and screening level.

| Order Number | Package Type<br>(Note 1) | Operating Range<br>(Note 2) | Screening Level<br>(Note 3)                          |
|--------------|--------------------------|-----------------------------|--|
| AM2920PC     | P-22                     | C                           | C-1  |
| AM2920DC     | D-22                     | C                           | C-1  |
| AM2920DC-B   | D-22                     | C                           | B-1  |
| AM2920DM     | D-22                     | M                           | C-3  |
| AM2920DM-B   | D-22                     | M                           | B-3  |
| AM2920FM     | F-22                     | M                           | C-3  |
| AM2920FM-B   | F-22                     | M                           | B-3  |
| AM2920XC     | Dice                     | C                           | Visual inspection<br>to MIL-STD-883<br>Method 2010B. |
| AM2920XM     | Dice                     | M                           |  |

- Notes: 1. P = Molded DIP, D = Hermetic DIP, F = Flat Pak. Number following letter is number of leads. See Appendix B for detailed outline.  
Where Appendix B contains several dash numbers, any of the variations of the package may be used unless otherwise specified.  
2. C =  $0^\circ\text{C to } +70^\circ\text{C}$ ,  $V_{CC} = 4.75\text{V to } 5.25\text{V}$ , M =  $-55^\circ\text{C to } +125^\circ\text{C}$ ,  $V_{CC} = 4.50\text{V to } 5.50\text{V}$ .  
3. See Appendix A for details of screening. Levels C-1 and C-3 conform to MIL-STD-883, Class C. Level B-3 conforms to MIL-STD-883, Class B.

**MAXIMUM RATINGS** (Above which the useful life may be impaired)

|   |                                |
|---|--------------------------------|
| Storage Temperature                                 | -65°C to +150°C                |
| Temperature (Ambient) Under Bias                    | -55°C to +125°C                |
| Supply Voltage to Ground Potential Continuous       | -0.5V to +7.0V                 |
| DC Voltage Applied to Outputs for High Output State | -0.5V to +V <sub>CC</sub> max. |
| DC Input Voltage                                    | -0.5V to +7.0V                 |
| DC Output Current, Into Outputs                     | 30mA                           |
| DC Input Current                                    | -30mA to +5.0mA                |

**SWITCHING CHARACTERISTICS**(T<sub>A</sub> = +25°C, V<sub>CC</sub> = 5.0V)

| Parameters       | Description                                    |          | Min. | Typ. | Max. | Units | Test Conditions                                  |
|------------------|--|----------|------|------|------|-------|--|
| t <sub>PLH</sub> | Clock to Y <sub>i</sub> ( $\overline{OE}$ LOW) |          |      | 18   | 27   | ns    | C <sub>L</sub> = 15pF<br>R <sub>L</sub> = 2.0kΩ  |
| t <sub>PHL</sub> |  |          |      | 24   | 36   |       |  |
| t <sub>PHL</sub> | Clear to Y                                     |          |      | 22   | 35   | ns    |  |
| t <sub>s</sub>   | Data (D <sub>i</sub> )                         |          | 10   | 3    |      | ns    |  |
| t <sub>h</sub>   | Data (D <sub>i</sub> )                         |          | 10   | 3    |      | ns    |  |
| t <sub>s</sub>   | Enable ( $\overline{E}$ )                      | Active   | 15   | 10   |      | ns    |  |
|                  |  | Inactive | 20   | 12   |      |       |  |
| t <sub>h</sub>   | Enable ( $\overline{E}$ )                      |          | 0    | 0    |      | ns    |  |
| t <sub>s</sub>   | Clear Recovery (In-Active) to Clock            |          | 11   | 7    |      | ns    |  |
| t <sub>pw</sub>  | Clock  | HIGH     | 20   | 14   |      | ns    |  |
|                  |  | LOW      | 25   | 13   |      |       |  |
| t <sub>pw</sub>  | Clear  |          | 20   | 13   |      | ns    |  |
| t <sub>ZH</sub>  | $\overline{OE}$ to Y <sub>i</sub>              |          |      | 9    | 13   | ns    |  |
| t <sub>ZL</sub>  |  |          |      | 14   | 21   |       |  |
| t <sub>HZ</sub>  | $\overline{OE}$ to Y <sub>i</sub>              |          |      | 20   | 30   | ns    | C <sub>L</sub> = 5.0pF<br>R <sub>L</sub> = 2.0kΩ |
| t <sub>LZ</sub>  |  |          |      | 24   | 36   |       |  |
| f <sub>max</sub> | Maximum Clock Frequency (Note 1)               |          |      | 40   |      | MHz   |  |

Note 1. Per industry convention, f<sub>max</sub> is the worst case value of the maximum device operating frequency with no constraints on t<sub>r</sub>, t<sub>f</sub>, pulse width or duty cycle.

**SWITCHING CHARACTERISTICS  
OVER OPERATING RANGE\***

| SWITCHING CHARACTERISTICS<br>OVER OPERATING RANGE* |  |          | Am2920PC,DC  |      | Am2920DM,FM  |      |       |  |
|--|--|----------|--|------|--|------|-------|--|
|  |  |          | T <sub>A</sub> = 0°C to +70°C<br>V <sub>CC</sub> = 5.0V ± 5% |      | T <sub>A</sub> = -55°C to +125°C<br>V <sub>CC</sub> = 5.0V ± 10% |      |       |  |
| Parameters   | Description                                    |          | Min.   | Max. | Min.   | Max. | Units | Test Conditions                                    |
| t <sub>PLH</sub>                                   | Clock to Y <sub>i</sub> ( $\overline{OE}$ LOW) |          |  | 33   |  | 39   | ns    | C <sub>L</sub> = 50pF<br>R <sub>L</sub> = 2.0kΩ    |
| t <sub>PHL</sub>                                   |  |          |  | 45   |  | 54   |       |  |
| t <sub>PHL</sub>                                   | Clear to Y                                     |          |  | 43   |  | 51   | ns    |  |
| t <sub>s</sub>                                     | Data (D <sub>i</sub> )                         |          | 12   |      | 15   |      | ns    |  |
| t <sub>h</sub>                                     | Data (D <sub>i</sub> )                         |          | 12   |      | 15   |      | ns    |  |
| t <sub>s</sub>                                     | Enable ( $\overline{E}$ )                      | Active   | 17   |      | 20   |      | ns    |  |
|  |  | Inactive | 20   |      | 23   |      |       |  |
| t <sub>h</sub>                                     | Enable ( $\overline{E}$ )                      |          | 0  |      | 0  |      | ns    |  |
| t <sub>s</sub>                                     | Clear Recovery (In-Active) to Clock            |          | 13   |      | 15   |      | ns    |  |
| t <sub>pw</sub>                                    | Clock  | HIGH     | 25   |      | 30   |      | ns    |  |
|  |  | LOW      | 30   |      | 35   |      |       |  |
| t <sub>pw</sub>                                    | Clear  |          | 22   |      | 25   |      | ns    |  |
| t <sub>ZH</sub>                                    | $\overline{OE}$ to Y <sub>i</sub>              |          |  | 19   |  | 25   | ns    |  |
| t <sub>ZL</sub>                                    |  |          |  | 30   |  | 39   |       |  |
| t <sub>HZ</sub>                                    | $\overline{OE}$ to Y <sub>i</sub>              |          |  | 35   |  | 40   | ns    |  |
| t <sub>LZ</sub>                                    |  |          |  | 39   |  | 42   |       |  |
| f <sub>max</sub>                                   | Maximum Clock Frequency (Note 1)               |          | 25   |      | 20   |      | MHz   | C <sub>L</sub> = 5.0 pF<br>R <sub>L</sub> = 2.0 kΩ |

\*AC performance over the operating temperature range is guaranteed by testing defined in Group A; Subgroup 9.

## DEFINITION OF FUNCTIONAL TERMS

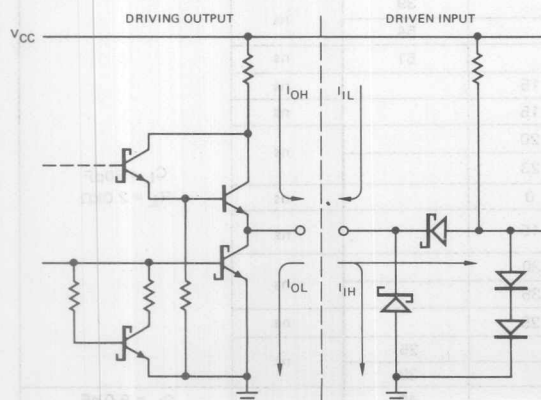
|                         |  |
|-------------------------|--|
| $D_i$                   | The D flip-flop data inputs.   |
| $\overline{\text{CLR}}$ | When the clear input is LOW, the $Q_i$ outputs are LOW, regardless of the other inputs. When the clear input is HIGH, data can be entered into the register.   |
| CP                      | Clock Pulse for the Register; enters data into the register on the LOW-to-HIGH transition.   |
| $Y_i$                   | The register three-state outputs.  |
| $\overline{\text{E}}$   | Clock Enable. When the clock enable is LOW, data on the $D_i$ input is transferred to the $Q_i$ output on the LOW-to-HIGH clock transition. When the clock enable is HIGH, the $Q_i$ outputs do not change state, regardless of the data or clock input transitions. |
| $\overline{\text{OE}}$  | Output Control. When the $\overline{\text{OE}}$ input is HIGH, the $Y_i$ outputs are in the high impedance state. When the $\overline{\text{OE}}$ input is LOW, the TRUE register data is present at the $Y_i$ outputs.  |

## FUNCTION TABLE

| Function | Inputs                 |                         |                       |       |    | Internal | Outputs |
|----------|------------------------|-------------------------|-----------------------|-------|----|----------|---------|
|          | $\overline{\text{OE}}$ | $\overline{\text{CLR}}$ | $\overline{\text{E}}$ | $D_i$ | CP | $Q_i$    | $Y_i$   |
| Hi-Z     | H                      | X                       | X                     | X     | X  | X        | Z       |
| Clear    | H                      | L                       | X                     | X     | X  | L        | Z       |
|          | L                      | L                       | X                     | X     | X  | L        | L       |
| Hold     | H                      | H                       | H                     | X     | X  | NC       | Z       |
|          | L                      | H                       | H                     | X     | X  | NC       | NC      |
| Load     | H                      | H                       | L                     | L     | ↑  | L        | Z       |
|          | H                      | H                       | L                     | H     | ↑  | H        | Z       |
|          | L                      | H                       | L                     | L     | ↑  | L        | L       |
|          | L                      | H                       | L                     | H     | ↑  | H        | H       |

H = HIGH  
L = LOW  
X = Don't Care

NC = No Change  
↑ = LOW-to-HIGH Transition  
Z = High Impedance

LOW-POWER SCHOTTKY INPUT/OUTPUT  
CURRENT INTERFACE CONDITIONS

Note: Actual current flow direction shown.

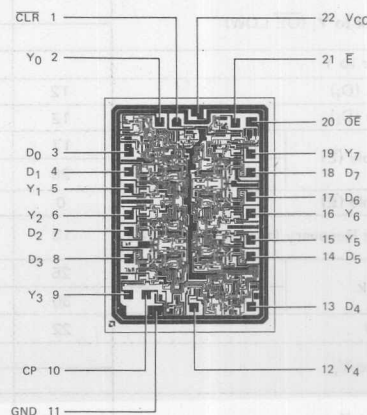
MPR-204

GUARANTEED LOADING RULES  
OVER OPERATING RANGE (In Unit Loads)

A Low-Power Schottky TTL Unit Load is defined as 20μA measured at 2.7V HIGH and -0.36mA measured at 0.4V LOW.

| Pin No.'s | Input/Output            | Am2920     |                       |                      |    |
|-----------|-------------------------|------------|-----------------------|----------------------|----|
|           |                         | Input Load | Output HIGH MIL COM'L | Output LOW MIL COM'L |    |
| 1         | $\overline{\text{CLR}}$ | 1          | —                     | —                    | —  |
| 2         | $Y_0$                   | —          | 50                    | 130                  | 22 |
| 3         | $D_0$                   | 1          | —                     | —                    | —  |
| 4         | $D_1$                   | 1          | —                     | —                    | —  |
| 5         | $Y_1$                   | —          | 50                    | 130                  | 22 |
| 6         | $Y_2$                   | —          | 50                    | 130                  | 22 |
| 7         | $D_2$                   | 1          | —                     | —                    | —  |
| 8         | $D_3$                   | 1          | —                     | —                    | —  |
| 9         | $Y_3$                   | —          | 50                    | 130                  | 22 |
| 10        | CP                      | 1          | —                     | —                    | —  |
| 11        | GND                     | —          | —                     | —                    | —  |
| 12        | $Y_4$                   | —          | 50                    | 130                  | 22 |
| 13        | $D_4$                   | 1          | —                     | —                    | —  |
| 14        | $D_5$                   | 1          | —                     | —                    | —  |
| 15        | $Y_5$                   | —          | 50                    | 130                  | 22 |
| 16        | $Y_6$                   | —          | 50                    | 130                  | 22 |
| 17        | $D_6$                   | 1          | —                     | —                    | —  |
| 18        | $D_7$                   | 1          | —                     | —                    | —  |
| 19        | $Y_7$                   | —          | 50                    | 130                  | 22 |
| 20        | $\overline{\text{OE}}$  | 1          | —                     | —                    | —  |
| 21        | $\overline{\text{E}}$   | 1          | —                     | —                    | —  |
| 22        | $V_{CC}$                | —          | —                     | —                    | —  |

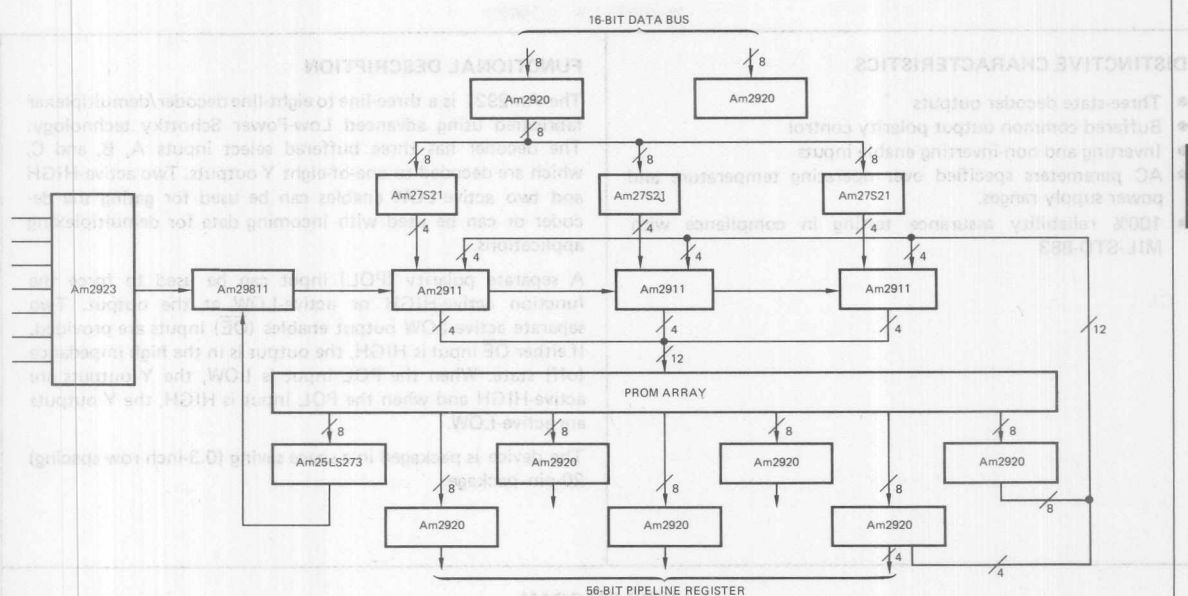
## Metallization and Pad Layout



DIE SIZE 0.080" X 0.111"

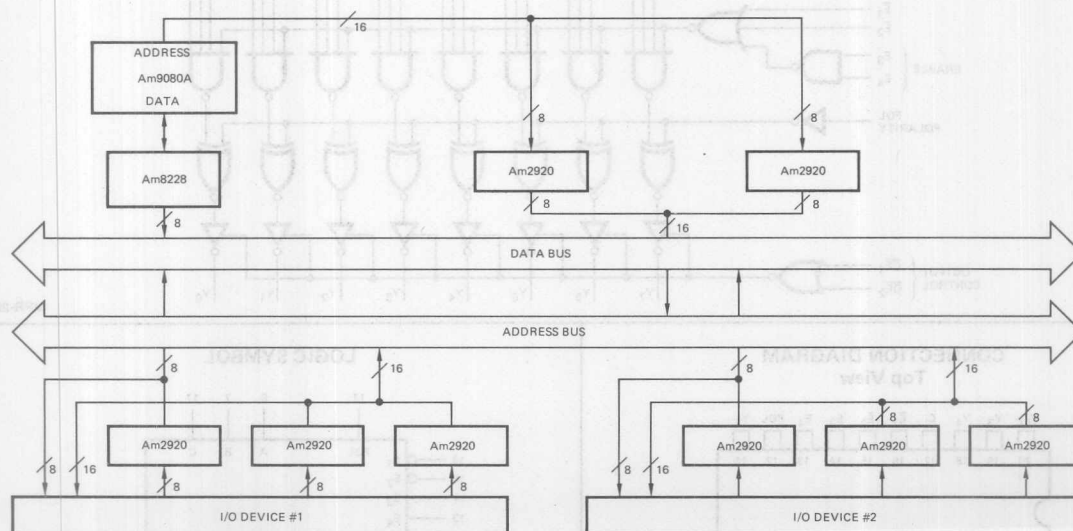


## APPLICATIONS



A typical Computer Control Unit for a microprogrammed machine.

MPR-205



The Am2920 is a useful device in interfacing with the Am9080A system buses.

MPR-206

## One-of-Eight Decoder With Three-State Outputs And Polarity Control

## DISTINCTIVE CHARACTERISTICS

- Three-state decoder outputs
- Buffered common output polarity control
- Inverting and non-inverting enable inputs
- AC parameters specified over operating temperature and power supply ranges.
- 100% reliability assurance testing in compliance with MIL-STD-883

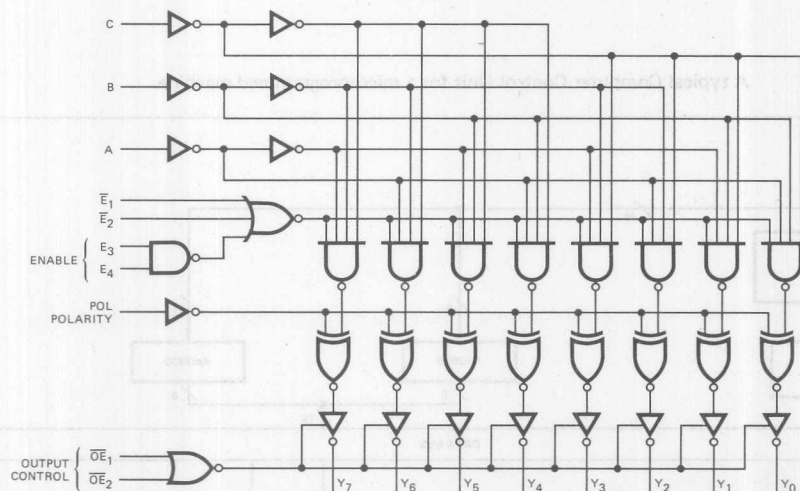
## FUNCTIONAL DESCRIPTION

The Am2921 is a three-line to eight-line decoder/demultiplexer fabricated using advanced Low-Power Schottky technology. The decoder has three buffered select inputs A, B, and C, which are decoded to one-of-eight Y outputs. Two active-HIGH and two active-LOW enables can be used for gating the decoder or can be used with incoming data for demultiplexing applications.

A separate polarity (POL) input can be used to force the function active-HIGH or active-LOW at the output. Two separate active-LOW output enables ( $\overline{OE}$ ) inputs are provided. If either  $\overline{OE}$  input is HIGH, the output is in the high impedance (off) state. When the POL input is LOW, the Y outputs are active-HIGH and when the POL input is HIGH, the Y outputs are active-LOW.

The device is packaged in a space saving (0.3-inch row spacing) 20-pin package.

### LOGIC DIAGRAM One-of-Eight Decoder



MPR-207

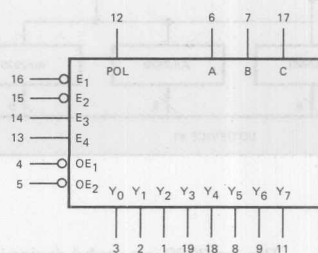
CONNECTION DIAGRAM  
Top View



Note: Pin 1 is marked for orientation.

MPR-208

LOGIC SYMBOL



V<sub>CC</sub> = Pin 20  
GND = Pin 10

MPR-209

**ELECTRICAL CHARACTERISTICS**

The Following Conditions Apply Unless Otherwise Specified:

COM'L  $T_A = 0^\circ\text{C to } +70^\circ\text{C}$   $V_{CC} = 5.0\text{V} \pm 5\%$  MIN. = 4.75V MAX. = 5.25V  
 MIL  $T_A = -55^\circ\text{C to } +125^\circ\text{C}$   $V_{CC} = 5.0\text{V} \pm 10\%$  MIN. = 4.50V MAX. = 5.50V

**DC CHARACTERISTICS OVER OPERATING RANGE**

| Parameters | Description                               | Test Conditions (Note 1)                                       |                                  | Min. | Typ.<br>(Note 2) | Max.  | Units         |
|------------|---|--|----------------------------------|------|------------------|-------|---------------|
| $V_{OH}$   | Output HIGH Voltage                       | $V_{CC} = \text{MIN.}$<br>$V_{IN} = V_{IH} \text{ or } V_{IL}$ | $I_{OH} = 1.0\text{mA (MIL)}$    | 2.4  | 3.4              |       | Volts         |
|            |   |  | $I_{OH} = -2.6\text{mA (COM'L)}$ | 2.4  | 3.4              |       |               |
| $V_{OL}$   | Output LOW Voltage                        | $V_{CC} = \text{MIN.}$<br>$V_{IN} = V_{IH} \text{ or } V_{IL}$ | $I_{OL} = 4.0\text{mA}$          |      |                  | 0.4   | Volts         |
|            |   |  | $I_{OL} = 8.0\text{mA}$          |      |                  | 0.45  |               |
|            |   |  | $I_{OL} = 12\text{mA}$           |      |                  | 0.5   |               |
| $V_{IH}$   | Input HIGH Level                          | Guaranteed input logical HIGH voltage for all inputs           |                                  | 2.0  |                  |       | Volts         |
| $V_{IL}$   | Input LOW Level                           | Guaranteed input logical LOW voltage for all inputs            | MIL                              |      |                  | 0.7   | Volts         |
|            |   |  | COM'L                            |      |                  | 0.8   |               |
| $V_I$      | Input Clamp Voltage                       | $V_{CC} = \text{MIN.}, I_{IN} = -18\text{mA}$                  |                                  |      |                  | -1.5  | Volts         |
| $I_{IL}$   | Input LOW Current                         | $V_{CC} = \text{MAX.}, V_{IN} = 0.4\text{V}$                   |                                  |      |                  | -0.36 | mA            |
| $I_{IH}$   | Input HIGH Current                        | $V_{CC} = \text{MAX.}, V_{IN} = 2.7\text{V}$                   |                                  |      |                  | 20    | $\mu\text{A}$ |
| $I_I$      | Input HIGH Current                        | $V_{CC} = \text{MAX.}, V_{IN} = 7.0\text{V}$                   |                                  |      |                  | 0.1   | mA            |
| $I_O$      | Off-State (High-Impedance) Output Current | $V_{CC} = \text{MAX.}$   | $V_O = 0.4\text{V}$              |      |                  | -20   | $\mu\text{A}$ |
|            |   |  | $V_O = 2.4\text{V}$              |      |                  | 20    |               |
| $I_{SC}$   | Output Short Circuit Current (Note 3)     | $V_{CC} = \text{MAX.}$   |                                  | -15  |                  | -85   | mA            |
| $I_{CC}$   | Power Supply Current (Note 4)             | $V_{CC} = \text{MAX.}$   |                                  |      | 21               | 34    | mA            |

Notes: 1. For conditions shown as MIN. or MAX., use the appropriate value specified under Electrical Characteristics for the applicable device type.

2. Typical limits are at  $V_{CC} = 5.0\text{V}$ ,  $25^\circ\text{C}$  ambient and maximum loading.

3. Not more than one output should be shorted at a time. Duration of the short circuit test should not exceed one second.

4. Test conditions: A = B = C =  $\bar{E}_1 = \bar{E}_2 = \text{GND}$ ;  $E_3 = E_4 = \text{POL}$ ;  $\bar{O}\bar{E}_1 = \bar{O}\bar{E}_2 = 4.5\text{V}$ .**MAXIMUM RATINGS** (Above which the useful life may be impaired)

|   |  |
|---|--|
| Storage Temperature                                 | $-65^\circ\text{C to } +150^\circ\text{C}$ |
| Temperature (Ambient) Under Bias                    | $-55^\circ\text{C to } +125^\circ\text{C}$ |
| Supply Voltage to Ground Potential Continuous       | $-0.5\text{V to } +7.0\text{V}$            |
| DC Voltage Applied to Outputs for High Output State | $-0.5\text{V to } +V_{CC} \text{ max.}$    |
| DC Input Voltage                                    | $-0.5\text{V to } +7.0\text{V}$            |
| DC Output Current, Into Outputs                     | 30mA                                       |
| DC Input Current                                    | $-30\text{mA to } +5.0\text{mA}$           |

Am2921

SWITCHING CHARACTERISTICS

(T<sub>A</sub> = +25°C, V<sub>CC</sub> = 5.0V)

| Parameters       | Description  | Min. | Typ. | Max. | Units | Test Conditions                                  |
|------------------|--|------|------|------|-------|--|
| t <sub>PLH</sub> | A, B, C to Y <sub>i</sub>                            |      | 20   | 30   | ns    | C <sub>L</sub> = 15pF<br>R <sub>L</sub> = 2.0kΩ  |
| t <sub>PHL</sub> |  |      | 15   | 22   |       |  |
| t <sub>PLH</sub> | $\overline{E_1}, \overline{E_2}$ to Y <sub>i</sub>   |      | 19   | 28   | ns    |  |
| t <sub>PHL</sub> |  |      | 20   | 30   |       |  |
| t <sub>PLH</sub> | E <sub>3</sub> , E <sub>4</sub> to Y <sub>i</sub>    |      | 21   | 31   | ns    |  |
| t <sub>PHL</sub> |  |      | 23   | 34   |       |  |
| t <sub>PLH</sub> | POL to Y <sub>i</sub>                                |      | 16   | 24   | ns    |  |
| t <sub>PHL</sub> |  |      | 20   | 30   |       |  |
| t <sub>ZH</sub>  | $\overline{OE_1}, \overline{OE_2}$ to Y <sub>i</sub> |      | 17   | 25   | ns    | C <sub>L</sub> = 5.0pF<br>R <sub>L</sub> = 2.0kΩ |
| t <sub>ZL</sub>  |  |      | 14   | 21   |       |  |
| t <sub>HZ</sub>  | $\overline{OE_1}, \overline{OE_2}$ to Y <sub>i</sub> |      | 17   | 25   | ns    |  |
| t <sub>LZ</sub>  |  |      | 20   | 30   |       |  |

SWITCHING CHARACTERISTICS  
OVER OPERATING RANGE\*

| Parameters       |  | Description | Am2921PC, DC   |      | Am2921DM, FM   |      | Units  | Test Conditions |
|------------------|--|-------------|--|------|--|------|--|-----------------|
|                  |  |             | T <sub>A</sub> = 0°C to +70°C<br>V <sub>CC</sub> = 5.0V ± 5% |      | T <sub>A</sub> = -55°C to +125°C<br>V <sub>CC</sub> = 5.0V ± 10% |      |  |                 |
|                  |  |             | Min.   | Max. | Min.   | Max. |  |                 |
| t <sub>PLH</sub> | A, B, C to Y <sub>i</sub>                            |             | 36   |      | 42   | ns   | C <sub>L</sub> = 50pF<br>R <sub>L</sub> = 2.0kΩ  |                 |
| t <sub>PHL</sub> |  |             | 29   |      | 37   |      |  |                 |
| t <sub>PLH</sub> | $\overline{E_1}, \overline{E_2}$ to Y <sub>i</sub>   |             | 34   |      | 39   | ns   |  |                 |
| t <sub>PHL</sub> |  |             | 38   |      | 45   |      |  |                 |
| t <sub>PLH</sub> | E <sub>3</sub> , E <sub>4</sub> to Y <sub>i</sub>    |             | 38   |      | 45   | ns   |  |                 |
| t <sub>PHL</sub> |  |             | 43   |      | 52   |      |  |                 |
| t <sub>PLH</sub> | POL to Y <sub>i</sub>                                |             | 29   |      | 34   | ns   | C <sub>L</sub> = 5.0pF<br>R <sub>L</sub> = 2.0kΩ |                 |
| t <sub>PHL</sub> |  |             | 39   |      | 49   |      |  |                 |
| t <sub>ZH</sub>  | $\overline{OE_1}, \overline{OE_2}$ to Y <sub>i</sub> |             | 38   |      | 45   | ns   |  |                 |
| t <sub>ZL</sub>  |  |             | 23   |      | 25   |      |  |                 |
| t <sub>HZ</sub>  | $\overline{OE_1}, \overline{OE_2}$ to Y <sub>i</sub> |             | 29   |      | 33   | ns   |  |                 |
| t <sub>LZ</sub>  |  |             | 33   |      | 36   |      |  |                 |

\* AC performance over the operating temperature range is guaranteed by testing defined in Group A, Subgroup 9.

**LOW-POWER SCHOTTKY INPUT/OUTPUT  
CURRENT INTERFACE CONDITIONS**

Note: Actual current flow direction shown.

MPR-210

**Metallization and Pad Layout**

DIE SIZE 0.081" X 0.096"



## DEFINITION OF FUNCTIONAL TERMS

**A, B, C, D** The three select inputs to the decoder/demultiplexer.

**$\bar{E}_1, \bar{E}_2$**  The active LOW enable inputs. A HIGH on either the  $\bar{E}_1$  or  $\bar{E}_2$  input forces all decoded functions to be disabled.

**$E_3, E_4$**  The active HIGH enable inputs. A LOW on either  $E_3$  or  $E_4$  inputs forces all the decoded functions to be inhibited.

**POL** Polarity Control. A LOW on the polarity control input forces the output to the active-HIGH state while a HIGH on the polarity control input forces the Y outputs to the active-LOW state.

**$\overline{OE}_1, \overline{OE}_2$**  Output Enable. When both the  $\overline{OE}_1$  and  $\overline{OE}_2$  inputs are LOW, the Y outputs are enabled. If either  $\overline{OE}_1$  or  $\overline{OE}_2$  input is HIGH, the Y outputs are in the high impedance state.

**$Y_i$**  The eight outputs for the decoder/demultiplexer.

# GUARANTEED LOADING RULES OVER OPERATING RANGE (In Unit Loads)

A Low-Power Schottky TTL Unit Load is defined as 20 $\mu$ A measured at 2.7V HIGH and -0.36mA measured at 0.4V LOW.

| Pin No.'s | Input/Output      | Input Load | Output HIGH |           | Output LOW |           |
|-----------|-------------------|------------|-------------|-----------|------------|-----------|
|           |                   |            | MIL COM'L   | MIL COM'L | MIL COM'L  | MIL COM'L |
| 1         | $Y_2$             | —          | 50          | 130       | 33         | 33        |
| 2         | $Y_1$             | —          | 50          | 130       | 33         | 33        |
| 3         | $Y_0$             | —          | 50          | 130       | 33         | 33        |
| 4         | $\overline{OE}_1$ | 1.0        | —           | —         | —          | —         |
| 5         | $\overline{OE}_2$ | 1.0        | —           | —         | —          | —         |
| 6         | A                 | 1.0        | —           | —         | —          | —         |
| 7         | B                 | 1.0        | —           | —         | —          | —         |
| 8         | $Y_5$             | —          | 50          | 130       | 33         | 33        |
| 9         | $Y_6$             | —          | 50          | 130       | 33         | 33        |
| 10        | GND               | —          | —           | —         | —          | —         |
| 11        | $Y_7$             | —          | 50          | 130       | 33         | 33        |
| 12        | POL               | 1.0        | —           | —         | —          | —         |
| 13        | $E_4$             | 1.0        | —           | —         | —          | —         |
| 14        | $E_3$             | 1.0        | —           | —         | —          | —         |
| 15        | $\bar{E}_2$       | 1.0        | —           | —         | —          | —         |
| 16        | $\bar{E}_1$       | 1.0        | —           | —         | —          | —         |
| 17        | C                 | 1.0        | —           | —         | —          | —         |
| 18        | $Y_4$             | —          | 50          | 130       | 33         | 33        |
| 19        | $Y_3$             | —          | 50          | 130       | 33         | 33        |
| 20        | $V_{CC}$          | —          | —           | —         | —          | —         |

## FUNCTION TABLE

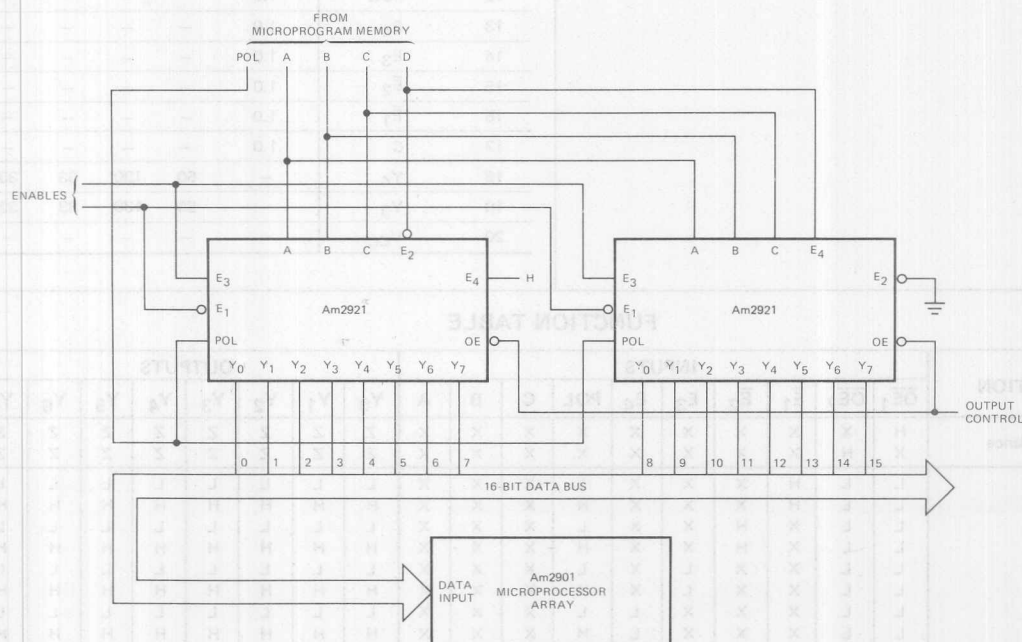
| FUNCTION           | INPUTS            |                   |             |             |       |       |     |   |   |   | OUTPUTS |       |       |       |       |       |       |       |
|--------------------|-------------------|-------------------|-------------|-------------|-------|-------|-----|---|---|---|---------|-------|-------|-------|-------|-------|-------|-------|
|                    | $\overline{OE}_1$ | $\overline{OE}_2$ | $\bar{E}_1$ | $\bar{E}_2$ | $E_3$ | $E_4$ | POL | C | B | A | $Y_0$   | $Y_1$ | $Y_2$ | $Y_3$ | $Y_4$ | $Y_5$ | $Y_6$ | $Y_7$ |
| High Impedance     | H                 | X                 | X           | X           | X     | X     | X   | X | X | X | Z       | Z     | Z     | Z     | Z     | Z     | Z     | Z     |
| Disable            | X                 | H                 | X           | X           | X     | X     | X   | X | X | X | Z       | Z     | Z     | Z     | Z     | Z     | Z     | Z     |
|                    | L                 | L                 | H           | X           | X     | X     | L   | X | X | X | L       | L     | L     | L     | L     | L     | L     | L     |
|                    | L                 | L                 | X           | H           | X     | X     | L   | X | X | X | L       | L     | L     | L     | L     | L     | L     | L     |
|                    | L                 | L                 | X           | X           | H     | X     | H   | X | X | X | H       | H     | H     | H     | H     | H     | H     | H     |
|                    | L                 | L                 | X           | X           | L     | X     | L   | X | X | X | L       | L     | L     | L     | L     | L     | L     | L     |
|                    | L                 | L                 | X           | X           | X     | L     | H   | X | X | X | L       | L     | L     | L     | L     | L     | L     | L     |
| Active-HIGH Output | L                 | L                 | L           | L           | H     | H     | L   | L | L | L | H       | L     | L     | L     | L     | L     | L     | L     |
|                    | L                 | L                 | L           | L           | H     | H     | L   | L | L | H | L       | H     | L     | L     | L     | L     | L     | L     |
|                    | L                 | L                 | L           | L           | H     | H     | L   | L | L | H | L       | L     | L     | L     | L     | L     | L     | L     |
|                    | L                 | L                 | L           | L           | H     | H     | L   | L | L | H | L       | L     | L     | L     | L     | L     | L     | L     |
|                    | L                 | L                 | L           | L           | H     | H     | L   | L | L | H | L       | L     | L     | L     | L     | L     | L     | L     |
|                    | L                 | L                 | L           | L           | H     | H     | L   | L | L | H | L       | L     | L     | L     | L     | L     | L     | L     |
| Active-LOW Output  | L                 | L                 | L           | L           | H     | H     | H   | L | L | L | H       | H     | H     | H     | H     | H     | H     | H     |
|                    | L                 | L                 | L           | L           | H     | H     | H   | L | L | L | H       | H     | H     | H     | H     | H     | H     | H     |
|                    | L                 | L                 | L           | L           | H     | H     | H   | L | L | L | H       | H     | H     | H     | H     | H     | H     | H     |
|                    | L                 | L                 | L           | L           | H     | H     | H   | L | L | L | H       | H     | H     | H     | H     | H     | H     | H     |
|                    | L                 | L                 | L           | L           | H     | H     | H   | L | L | L | H       | H     | H     | H     | H     | H     | H     | H     |
|                    | L                 | L                 | L           | L           | H     | H     | H   | L | L | L | H       | H     | H     | H     | H     | H     | H     | H     |

H = HIGH    L = LOW    X = Don't Care    Z = High Impedance

| Order Number | Package Type<br>(Note 1) | Operating Range<br>(Note 2) | Screening Level<br>(Note 3)                          |
|--------------|--------------------------|-----------------------------|--|
| AM2921PC     | P-20                     | C                           | C-1  |
| AM2921DC     | D-20                     | C                           | C-1  |
| AM2921DC-B   | D-20                     | C                           | B-1  |
| AM2921DM     | D-20                     | M                           | C-3  |
| AM2921DM-B   | D-20                     | M                           | B-3  |
| AM2921FM     | F-20                     | M                           | C-3  |
| AM2921FM-B   | F-20                     | M                           | B-3  |
| AM2921XC     | Dice                     | C                           | Visual inspection<br>to MIL-STD-883<br>Method 2010B. |
| AM2921XM     | Dice                     | M                           |  |

- Notes: 1. P = Molded DIP, D = Hermetic DIP, F = Flat Pak. Number following letter is number of leads. See Appendix B for detailed outline. Where Appendix B contains several dash numbers, any of the variations of the package may be used unless otherwise specified.
2. C = 0°C to +70°C,  $V_{CC} = 4.75V$  to 5.25V, M = -55°C to +125°C,  $V_{CC} = 4.50V$  to 5.50V.
3. See Appendix A for details of screening. Levels C-1 and C-3 conform to MIL-STD-883, Class C. Level B-3 conforms to MIL-STD-883, Class B.

## APPLICATIONS



MPR-211

Two Am2921's can be used to perform a bit set, bit clear, bit toggle or bit test on any of sixteen bits in a microprocessor system. Examples of the operations performed are as follows:

| Microprogram Control |   |   |   |     | 16-Bit Field From Am2921 |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    | Am2901 ALU Function | Bit Function Performed On Selected Register |            |
|----------------------|---|---|---|-----|--------------------------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|---------------------|---|------------|
| D                    | C | B | A | POL | 0                        | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |                     |   |            |
| 0                    | 0 | 1 | 1 | 0   | 0                        | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0  | 0  | 0  | 0  | 0  | 0  | 0                   | OR  | BIT SET    |
| 1                    | 1 | 0 | 0 | 0   | 0                        | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0  | 0  | 0  | 1  | 0  | 0  | 0                   | AND   | BIT TEST   |
| 0                    | 1 | 1 | 0 | 1   | 1                        | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1  | 1  | 1  | 1  | 1  | 1  | 1                   | AND   | BIT CLEAR  |
| 1                    | 0 | 1 | 0 | 1   | 1                        | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1  | 1  | 1  | 1  | 1  | 1  | 1                   | EX NOR                                      | BIT TOGGLE |
| 1                    | 0 | 1 | 0 | 0   | 0                        | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1  | 0  | 0  | 0  | 0  | 0  | 0                   | EX OR                                       | BIT TOGGLE |

Note: Bit test is performed using F = 0 output of Am2901A.

# Am2922

## Eight Input Multiplexer With Control Register

### DISTINCTIVE CHARACTERISTICS

- High speed eight-input multiplexer
- On-chip Multiplexer Select and Polarity Control Register
- Output polarity control for inverting or non-inverting output
- Common register enable
- Asynchronous register clear
- Three-state output for expansion
- AC parameters specified over operating temperature and power supply ranges.
- 100% product assurance testing to MIL-STD-883 requirements

### FUNCTIONAL DESCRIPTION

The Am2922 is an eight-input Multiplexer with Control Register. The device features high speed from clock to output and is intended for use in high speed computer control units or structured state machine designs.

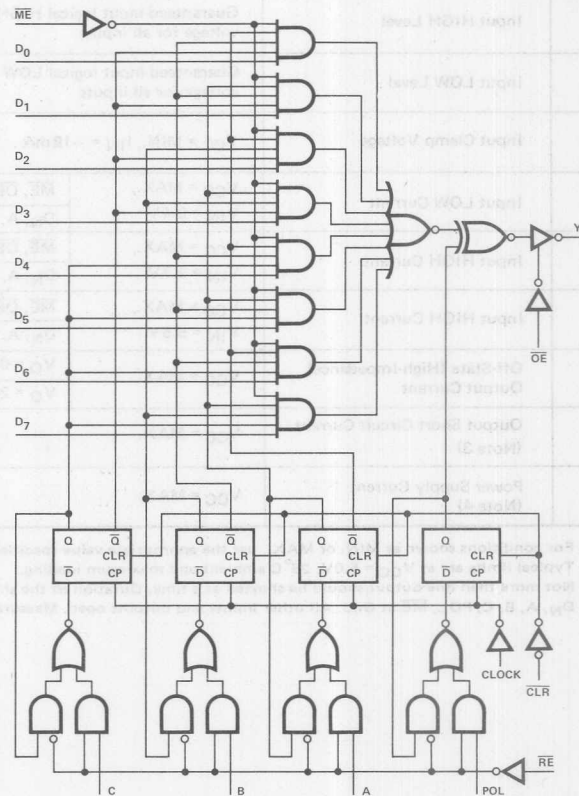
The Am2922 contains an internal register which holds the A, B and C multiplexer select lines as well as the POL (Polarity) control bit. When the Register Enable input ( $\overline{RE}$ ) is LOW, new data is entered into the register on the LOW-to-HIGH transition of the clock. When  $\overline{RE}$  is HIGH, the register retains its current data. An asynchronous clear input ( $\overline{CLR}$ ) is used to reset the register to a logic LOW level.

The A, B and C register outputs select one of eight multiplexer data inputs. A HIGH on the Polarity Control flip-flop output causes a true (non-inverting) multiplexer output, and a LOW causes the output to be inverted. In a computer control unit, this allows testing of either true or complemented flag data at the microprogram sequencer test input.

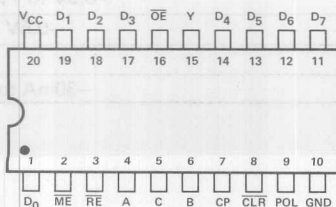
An active LOW Multiplexer Enable input ( $\overline{ME}$ ) allows the selected multiplexer input to be passed to the output. When  $\overline{ME}$  is HIGH, the output is determined only by the Polarity Control bit.

The Am2922 also features a three-state Output Enable control ( $\overline{OE}$ ) for expansion. When  $\overline{OE}$  is LOW, the output is enabled. When  $\overline{OE}$  is HIGH, the output is in the high impedance state.

### LOGIC DIAGRAM



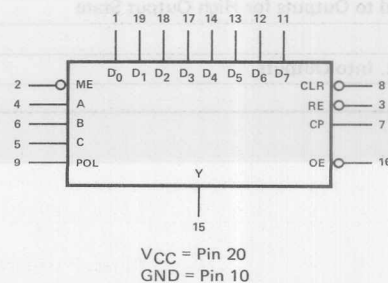
### CONNECTION DIAGRAM Top View



Note: Pin 1 is marked for orientation.

MPR-212

### LOGIC SYMBOL



$V_{CC}$  = Pin 20  
GND = Pin 10

MPR-214

## ELECTRICAL CHARACTERISTICS

The Following Conditions Apply Unless Otherwise Specified:

COM'L  $T_A = 0^\circ\text{C to } +70^\circ\text{C}$   $V_{CC} = 5.0\text{V} \pm 5\%$  MIN. = 4.75V MAX. = 5.25VMIL  $T_A = -55^\circ\text{C to } +125^\circ\text{C}$   $V_{CC} = 5.0\text{V} \pm 10\%$  MIN. = 4.50V MAX. = 5.50V

## DC CHARACTERISTICS OVER OPERATING RANGE

| Parameters | Description                               | Test Conditions (Note 1)                                       |   | Min. | Typ.<br>(Note 2) | Max.               | Units         |
|------------|---|--|---|------|------------------|--------------------|---------------|
| $V_{OH}$   | Output HIGH Voltage                       | $V_{CC} = \text{MIN.}$<br>$V_{IN} = V_{IH} \text{ or } V_{IL}$ | MIL, $I_{OH} = -2.0\text{mA}$<br>COM'L, $I_{OH} = -6.5\text{mA}$                                | 2.4  | 3.4              |                    | Volts         |
| $V_{OL}$   | Output LOW Voltage                        | $V_{CC} = \text{MIN.}$<br>$V_{IN} = V_{IH} \text{ or } V_{IL}$ | $I_{OL} = 4.0\text{mA}$<br>$I_{OL} = 8.0\text{mA}$<br>$I_{OL} = 20\text{mA}$                    |      |                  | 0.4<br>0.45<br>0.5 | Volts         |
| $V_{IH}$   | Input HIGH Level                          | Guaranteed input logical HIGH voltage for all inputs           |   | 2.0  |                  |                    | Volts         |
| $V_{IL}$   | Input LOW Level                           | Guaranteed input logical LOW voltage for all inputs            |   |      |                  | 0.7<br>0.8         | Volts         |
| $V_I$      | Input Clamp Voltage                       | $V_{CC} = \text{MIN.}, I_{IN} = -18\text{mA}$                  |   |      |                  | -1.5               | Volts         |
| $I_{IL}$   | Input LOW Current                         | $V_{CC} = \text{MAX.},$<br>$V_{IN} = 0.4\text{V}$              | $\overline{ME}, \overline{OE}, \overline{RE}$<br>$D_N, A, B, C, \text{POL}, CP, \overline{CLR}$ |      |                  | -0.72<br>-2.0      | mA            |
| $I_{IH}$   | Input HIGH Current                        | $V_{CC} = \text{MAX.},$<br>$V_{IN} = 2.7\text{V}$              | $\overline{ME}, \overline{OE}, \overline{RE}$<br>$D_N, A, B, C, \text{POL}, CP, \overline{CLR}$ |      |                  | 40<br>50           | $\mu\text{A}$ |
| $I_I$      | Input HIGH Current                        | $V_{CC} = \text{MAX.},$<br>$V_{IN} = 5.5\text{V}$              | $\overline{ME}, \overline{OE}, \overline{RE}$<br>$D_N, A, B, C, \text{POL}, CP, \overline{CLR}$ |      |                  | 0.1<br>1.0         | mA            |
| $I_{OZ}$   | Off-State (High-Impedance) Output Current | $V_{CC} = \text{MAX.}$   | $V_O = 0.4\text{V}$<br>$V_O = 2.4\text{V}$  |      |                  | -50<br>50          | $\mu\text{A}$ |
| $I_{SC}$   | Output Short Circuit Current (Note 3)     | $V_{CC} = \text{MAX.}$   |   | -40  |                  | -100               | mA            |
| $I_{CC}$   | Power Supply Current (Note 4)             | $V_{CC} = \text{MAX.}$   |   |      | 97               | 148                | mA            |

Notes: 1. For conditions shown as MIN. or MAX., use the appropriate value specified under Electrical Characteristics for the applicable device type.

2. Typical limits are at  $V_{CC} = 5.0\text{V}$ ,  $25^\circ\text{C}$  ambient and maximum loading.

3. Not more than one output should be shorted at a time. Duration of the short circuit test should not exceed one second.

4.  $D_N, A, B, C, \text{POL}, \overline{ME}$  at Gnd. All other inputs and outputs open. Measured after a momentary ground then 4.5V applied to clock input.

## MAXIMUM RATINGS (Above which the useful life may be impaired)

|   |  |
|---|--|
| Storage Temperature                                 | $-65^\circ\text{C to } +150^\circ\text{C}$ |
| Temperature (Ambient) Under Bias                    | $-55^\circ\text{C to } +125^\circ\text{C}$ |
| Supply Voltage to Ground Potential Continuous       | $-0.5\text{V to } +7.0\text{V}$            |
| DC Voltage Applied to Outputs for High Output State | $-0.5\text{V to } +V_{CC} \text{ max.}$    |
| DC Input Voltage                                    | $-0.5\text{V to } +5.5\text{V}$            |
| DC Output Current, Into Outputs                     | 30mA                                       |
| DC Input Current                                    | $-30\text{mA to } +5.0\text{mA}$           |

## SWITCHING CHARACTERISTICS

(T<sub>A</sub> = +25°C, V<sub>CC</sub> = 5.0V)

| Parameters       | Description           | Min. | Typ. | Max. | Units | Test Conditions                                 |
|------------------|-----------------------|------|------|------|-------|---|
| t <sub>PLH</sub> | Clock to Y POL – LOW  |      | 21   | 32   | ns    | C <sub>L</sub> = 15pF<br>R <sub>L</sub> = 2.0kΩ |
| t <sub>PHL</sub> |                       |      | 19   | 29   |       |   |
| t <sub>PLH</sub> | Clock to Y POL – HIGH |      | 16   | 24   | ns    |   |
| t <sub>PHL</sub> |                       |      | 19   | 29   |       |   |
| t <sub>PLH</sub> | D <sub>n</sub> to Y   |      | 10   | 16   | ns    |   |
| t <sub>PHL</sub> |                       |      | 13   | 19   |       |   |
| t <sub>PLH</sub> | CLR to Y              |      | 22   | 33   | ns    |   |
| t <sub>PHL</sub> |                       |      | 22   | 33   |       |   |
| t <sub>PLH</sub> | ME to Y               |      | 12   | 18   | ns    |   |
| t <sub>PHL</sub> |                       |      | 12   | 18   |       |   |
| t <sub>ZL</sub>  | OE to Y               |      | 8    | 14   | ns    |   |
| t <sub>ZH</sub>  |                       |      | 8    | 14   |       |   |
| t <sub>LZ</sub>  |                       |      | 10   | 17   | ns    |   |
| t <sub>HZ</sub>  |                       |      | 10   | 17   |       |   |
| t <sub>S</sub>   | A, B, C, POL          | 10   |      |      | ns    | C <sub>L</sub> = 15pF<br>R <sub>L</sub> = 2.0kΩ |
|                  | CE                    | 15   |      |      |       |   |
| t <sub>S</sub>   | CLR Recovery          | 5    |      |      | ns    |   |
| t <sub>pw</sub>  | Clock                 | 10   |      |      | ns    |   |
|                  | Clear (LOW)           | 10   |      |      |       |   |
| t <sub>h</sub>   | A, B, C, POL, CE      | 0    |      |      | ns    |   |

SWITCHING CHARACTERISTICS  
OVER OPERATING RANGE\*

| SWITCHING CHARACTERISTICS<br>OVER OPERATING RANGE* |                   | Am2922PC, DC  |      | Am2922DM, FM  |      | Units | Test Conditions                                   |
|--|-------------------|---|------|---|------|-------|---|
|  |                   | $T_A = 0^{\circ}\text{C to } +70^{\circ}\text{C}$<br>$V_{CC} = 5.0\text{V} \pm 5\%$ |      | $T_A = -55^{\circ}\text{C to } +125^{\circ}\text{C}$<br>$V_{CC} = 5.0\text{V} \pm 10\%$ |      |       |   |
|  |                   | Min.  | Max. | Min.  | Max. |       |   |
| Parameters   | Description       |   |      |   |      |       |   |
| $t_{PLH}$  | Clock to Y, POL-L |   | 40   |   | 47   | ns    | $C_L = 50\text{pF}$<br>$R_L = 2.0\text{k}\Omega$  |
| $t_{PHL}$  |                   |   | 34   |   | 38   |       |   |
| $t_{PLH}$  | Clock to Y, POL-H |   | 29   |   | 33   | ns    |   |
| $t_{PHL}$  |                   |   | 35   |   | 41   |       |   |
| $t_{PLH}$  | $D_N$ to Y        |   | 19   |   | 21   | ns    |   |
| $t_{PHL}$  |                   |   | 22   |   | 24   |       |   |
| $t_{PLH}$  | CLR to Y          |   | 39   |   | 45   | ns    |   |
| $t_{PHL}$  |                   |   | 39   |   | 45   |       |   |
| $t_{PLH}$  | ME to Y           |   | 22   |   | 26   | ns    |   |
| $t_{PHL}$  |                   |   | 19   |   | 20   |       |   |
| $t_{ZL}$   | OE to Y           |   | 19   |   | 24   | ns    |   |
| $t_{ZH}$   |                   |   | 22   |   | 29   |       |   |
| $t_{LZ}$   | OE to Y           |   | 24   |   | 30   | ns    | $C_L = 5.0\text{pF}$<br>$R_L = 2.0\text{k}\Omega$ |
| $t_{HZ}$   |                   |   | 24   |   | 30   |       |   |
| $t_s$  | A, B, C POL       | 11  |      | 12  |      | ns    | $C_L = 50\text{pF}$<br>$R_L = 2.0\text{k}\Omega$  |
|  | CE                | 18  |      | 20  |      |       |   |
| $t_s$  | CLR Recovery      | 6   |      | 7   |      | ns    |   |
| $t_{pw}$   | Clock             | 11  |      | 12  |      | ns    |   |
|  | Clear (LOW)       | 11  |      | 12  |      |       |   |
| $t_H$  | A, B, C, POL, CE  | 3   |      | 3   |      | ns    |   |

\* AC performance over the operating temperature range is guaranteed by testing defined in Group A, Subgroup 9.



|     |   |                                |   |
|-----|---|--------------------------------|---|
| POL | data inputs is selected by the A, B and C register outputs.   | D <sub>1</sub> -D <sub>8</sub> | Select and Polarity Control Register.   |
| ME  | Polarity Control Bit. A HIGH register output causes a true (non-inverted) output and a LOW causes the output to be inverted.                            | CP                             | Data Inputs to the 8-input multiplexer.   |
| RE  | Multiplexer Enable. When LOW, it enabled the 8-input multiplexer. When HIGH, the Y output is determined by only the Polarity Control bit.               | OE                             | Clock Pulse. When $\overline{RE}$ is LOW, the Multiplexer Select and Polarity Control Register changes state on the LOW-to-HIGH transition of CP. |
|     | Register Enable. When LOW, the Multiplexer Select and Polarity Control Register is enabled for loading. When HIGH, the register holds its current data. | Y                              | Output Enable. When LOW, the output is enabled. When HIGH, the output is in the high impedance state.   |
|     |   |                                | The chip output.  |

FUNCTION TABLE

| MODE                           | INPUTS |   |   |     |                 |                  |    | INTERNAL       |                |                |                  | INPUTS          |                 | OUTPUT                           |
|--------------------------------|--------|---|---|-----|-----------------|------------------|----|----------------|----------------|----------------|------------------|-----------------|-----------------|----------------------------------|
|                                | C      | B | A | POL | $\overline{RE}$ | $\overline{CLR}$ | CP | Q <sub>C</sub> | Q <sub>B</sub> | Q <sub>A</sub> | Q <sub>POL</sub> | $\overline{ME}$ | $\overline{OE}$ | Y                                |
| Clear                          | X      | X | X | X   | X               | L                | X  | L              | L              | L              | L                | H               | L               | H                                |
|                                | ↓      | ↓ | ↓ | ↓   | ↓               | ↓                | ↓  | ↓              | ↓              | ↓              | ↓                | L               | L               | $\overline{D_0}$                 |
|                                |        |   |   |     |                 |                  |    |                |                |                |                  | X               | H               | Z                                |
| Reg. Disable                   | X      | X | X | X   | H               | H                | X  | NC             | NC             | NC             | NC               | L               | L               | $\overline{D_1}/D_1$<br>(Note 1) |
| Select<br>(Multiplex)          | L      | L | L | L/H | L               | H                | ↑  | L              | L              | L              | L/H              | L               | L               | $\overline{D_0}/D_0$             |
|                                | L      | L | H | ↓   | ↓               | ↓                | ↓  | L              | L              | H              | ↓                | ↓               | ↓               | $\overline{D_1}/D_1$             |
|                                | L      | H | L | ↓   | ↓               | ↓                | ↓  | L              | H              | L              | ↓                | ↓               | ↓               | $\overline{D_2}/D_2$             |
|                                | L      | H | H | ↓   | ↓               | ↓                | ↓  | L              | H              | H              | ↓                | ↓               | ↓               | $\overline{D_3}/D_3$             |
|                                | H      | L | L | ↓   | ↓               | ↓                | ↓  | H              | L              | L              | ↓                | ↓               | ↓               | $\overline{D_4}/D_4$             |
|                                | H      | L | H | ↓   | ↓               | ↓                | ↓  | H              | L              | H              | ↓                | ↓               | ↓               | $\overline{D_5}/D_5$             |
|                                | H      | H | L | ↓   | ↓               | ↓                | ↓  | H              | H              | L              | ↓                | ↓               | ↓               | $\overline{D_6}/D_6$             |
|                                | H      | H | H | ↓   | ↓               | ↓                | ↓  | H              | H              | H              | ↓                | ↓               | ↓               | $\overline{D_7}/D_7$             |
| Multiplexer<br>Disable         | X      | X | X | X   | X               | H                | X  | X              | X              | X              | L                | H               | L               | H                                |
|                                | ↓      | ↓ | ↓ | ↓   | ↓               | ↓                | ↓  | X              | X              | X              | H                | H               | L               | L                                |
| Tri-state<br>Output<br>Disable | ↓      | ↓ | ↓ | ↓   | ↓               | ↓                | ↓  | X              | X              | X              | X                | X               | H               | Z                                |

NC = No Change  
X = Don't Care

Note 1: The output will follow the selected input,  $D_i$ , or its complement depending on the state of the POL flip-flop.

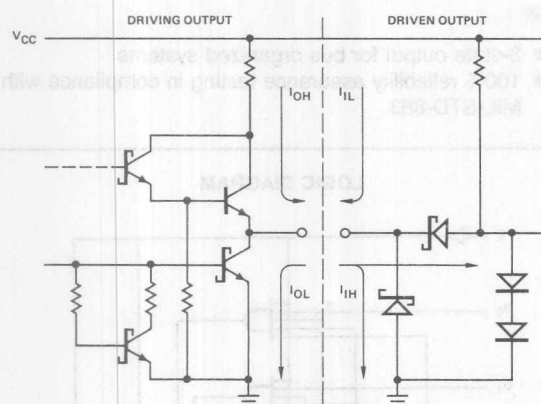
# ORDERING INFORMATION

Order the part number according to the table below to obtain the desired package, temperature range, and screening level.

| Order Number | Package Type<br>(Note 1) | Operating Range<br>(Note 2) | Screening Level<br>(Note 3)                          |
|--------------|--------------------------|-----------------------------|--|
| AM2922PC     | P-20                     | C                           | C-1  |
| AM2922DC     | D-20                     | C                           | C-1  |
| AM2922DC-B   | D-20                     | C                           | B-1  |
| AM2922DM     | D-20                     | M                           | C-3  |
| AM2922DM-B   | D-20                     | M                           | B-3  |
| AM2922FM     | F-20                     | M                           | C-3  |
| AM2922FM-B   | F-20                     | M                           | B-3  |
| AM2922XC     | Dice                     | C                           | Visual inspection<br>to MIL-STD-883<br>Method 2010B. |
| AM2922XM     | Dice                     | M                           |  |

- Notes: 1. P = Molded DIP, D = Hermetic DIP, F = Flat Pak. Number following letter is number of leads. See Appendix B for detailed outline. Where Appendix B contains several dash numbers, any of the variations of the package may be used unless otherwise specified.
2. C = 0°C to +70°C, V<sub>CC</sub> = 4.75V to 5.25V, M = -55°C to +125°C, V<sub>CC</sub> = 4.50V to 5.50V.
3. See Appendix A for details of screening. Levels C-1 and C-3 conform to MIL-STD-883, Class C. Level B-3 conforms to MIL-STD-883, Class B.

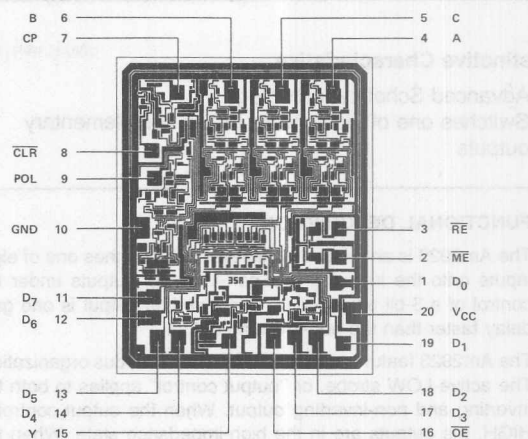
# LOW-POWER SCHOTTKY INPUT/OUTPUT CURRENT INTERFACE CONDITIONS



Note: Actual current flow direction shown.

MPR-215

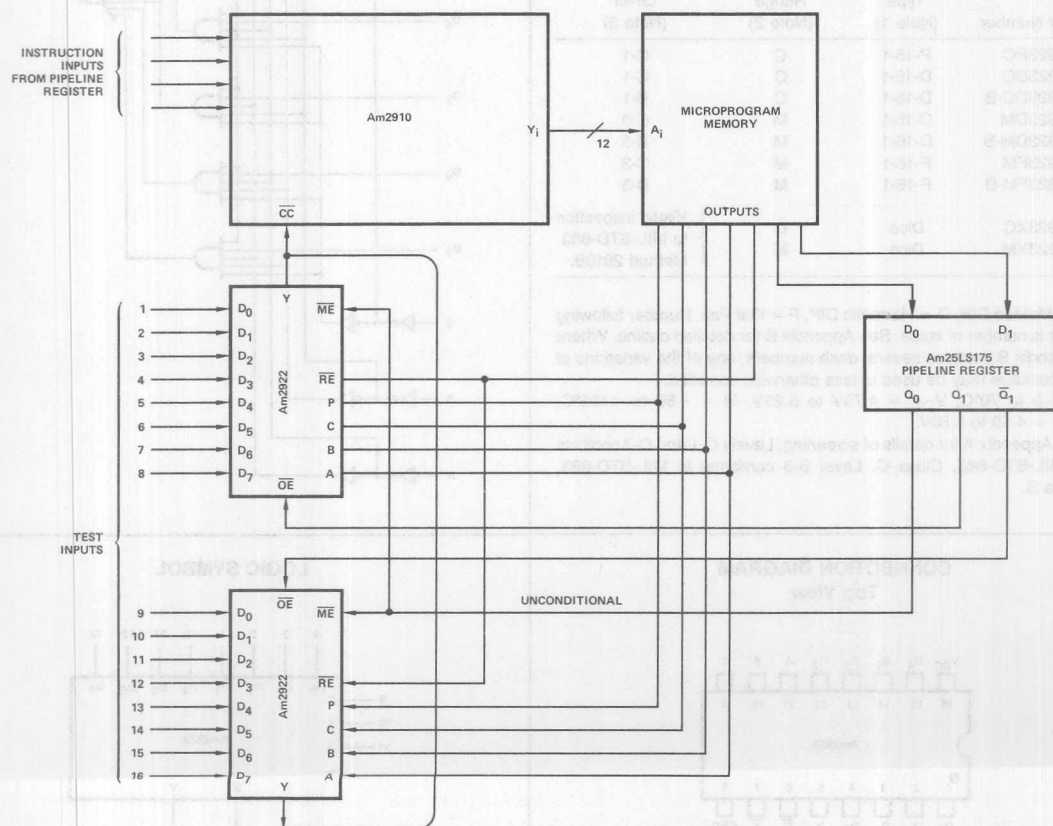
# Metallization and Pad Layout



DIE SIZE 0.080" X 0.099"

2

# APPLICATION



A versatile one-of-sixteen Test Select with Polarity Control and Test Select Hold.

MPR-216

# Am2923

## Eight-Input Multiplexer

### Distinctive Characteristics

- Advanced Schottky technology
- Switches one of eight inputs to two complementary outputs
- 3-state output for bus organized systems
- 100% reliability assurance testing in compliance with MIL-STD-883

### FUNCTIONAL DESCRIPTION

The Am2923 is an 8-input multiplexer that switches one of eight inputs onto the inverting and non-inverting outputs under the control of a 3-bit select code. The inverting output is one gate delay faster than the non-inverting output.

The Am2923 features a 3-state output for data bus organization. The active-LOW strobe, or "output control" applies to both the inverting and non-inverting output. When the output control is HIGH, the outputs are in the high-impedance state. When the output control is LOW, the active pull-up output is enabled.

### ORDERING INFORMATION

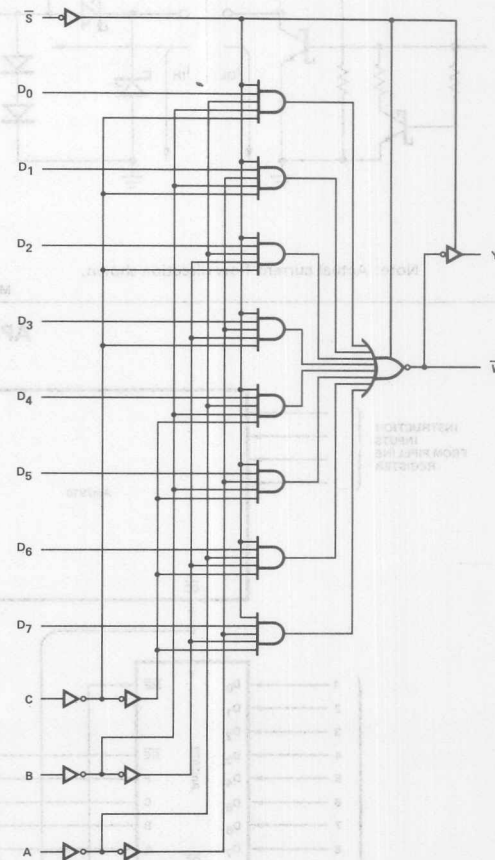
Order the part number according to the table below to obtain the desired package, temperature range and screening level.

| Order Number | Package Type<br>(Note 1) | Operating Range<br>(Note 2) | Screening Level<br>(Note 3)                          |
|--------------|--------------------------|-----------------------------|--|
| AM2923PC     | P-16-1                   | C                           | C-1  |
| AM2923DC     | D-16-1                   | C                           | C-1  |
| AM2923DC-B   | D-16-1                   | C                           | B-1  |
| AM2923DM     | D-16-1                   | M                           | C-3  |
| AM2923DM-B   | D-16-1                   | M                           | B-3  |
| AM2923FM     | F-16-1                   | M                           | C-3  |
| AM2923FM-B   | F-16-1                   | M                           | B-3  |
| AM2923XC     | Dice                     | C                           | Visual inspection<br>to MIL-STD-883<br>Method 2010B. |
| AM2923XM     | Dice                     | M                           |  |

Notes:

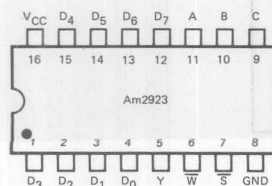
1. P = Molded DIP, D = Hermetic DIP, F = Flat Pak. Number following letter is number of leads. See Appendix B for detailed outline. Where Appendix B contains several dash numbers, any of the variations of the package may be used unless otherwise specified.
2. C = 0 to 70°C,  $V_{CC} = 4.75V$  to 5.25V, M = -55 to +125°C,  $V_{CC} = 4.50$  to 5.50V.
3. See Appendix A for details of screening. Levels C-1 and C-3 conform to MIL-STD-883, Class C. Level B-3 conforms to MIL-STD-883, Class B.

### LOGIC DIAGRAM



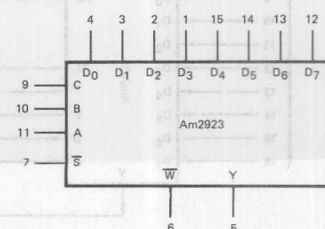
BLI-069

### CONNECTION DIAGRAM Top View



BLI-070

### LOGIC SYMBOL



BLI-071

**MAXIMUM RATINGS** (Above which the useful life may be impaired).

|   |                                |
|---|--------------------------------|
| Storage Temperature   | -65°C to +150°C                |
| Temperature (Ambient) Under Bias                                | -55°C to +125°C                |
| Supply Voltage to Ground Potential (Pin 16 to Pin 8) Continuous | -0.5V to +7V                   |
| DC Voltage Applied to Outputs for HIGH Output State             | -0.5V to +V <sub>CC</sub> max. |
| DC Input Voltage  | -0.5V to +5.5V                 |
| DC Output Current, Into Output                                  | 30mA                           |
| DC Input Current  | -30mA to +5.0mA                |

**ELECTRICAL CHARACTERISTICS OVER OPERATING TEMPERATURE RANGE** (Unless Otherwise Noted)

Am2923PC, DC, XC    T<sub>A</sub> = 0 to 70°C    V<sub>CC</sub> = 5.0V ±5% (COM'L)    MIN = 4.75V    MAX = 5.25V  
 Am2923DM, FM, XM    T<sub>A</sub> = -55 to +125°C    V<sub>CC</sub> = 5.0V ±10% (MIL)    MIN = 4.5V    MAX = 5.5V

| Parameters                  | Description                                  | Test Conditions (Note 1)   |  | Min                      | Typ<br>(Note 2) | Max       | Units |
|-----------------------------|--|--|--|--------------------------|-----------------|-----------|-------|
| V <sub>OH</sub>             | Output HIGH Voltage                          | MIL  | V <sub>CC</sub> = MIN,<br>V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub> | I <sub>OH</sub> = -2mA   | 2.4             | 3.4       | Volts |
|                             |  | COM'L  |  | I <sub>OH</sub> = -6.5mA | 2.4             | 3.2       |       |
| V <sub>OL</sub>             | Output LOW Voltage                           | V <sub>CC</sub> = MIN, I <sub>OL</sub> = 20mA<br>V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>                      |  |                          |                 | 0.5       | Volts |
| V <sub>IH</sub>             | Input HIGH Level                             | Guaranteed input logical HIGH voltage for all inputs   |  | 2                        |                 |           | Volts |
| V <sub>IL</sub>             | Input LOW Level                              | Guaranteed input logical LOW voltage for all inputs  |  |                          |                 | 0.8       | Volts |
| V <sub>I</sub>              | Input Clamp Voltage                          | V <sub>CC</sub> = MIN, I <sub>IN</sub> = -18mA   |  |                          |                 | -1.2      | Volts |
| I <sub>IL</sub><br>(Note 3) | Unit Load<br>Input LOW Current               | V <sub>CC</sub> = MAX, V <sub>IN</sub> = 0.5   |  |                          |                 | -2        | mA    |
| I <sub>IH</sub><br>(Note 3) | Unit Load<br>Input HIGH Current              | V <sub>CC</sub> = MAX, V <sub>IN</sub> = 2.7   |  |                          |                 | 50        | μA    |
| I <sub>I</sub>              | Input HIGH Current                           | V <sub>CC</sub> = MAX, V <sub>IN</sub> = 5.5V  |  |                          |                 | 1         | mA    |
| I <sub>O(off)</sub>         | Off-State (High-Impedance)<br>Output Current | V <sub>CC</sub> = MAX, V <sub>O</sub> = 2.4V<br>V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub> V <sub>O</sub> = 0.5V |  |                          |                 | 50<br>-50 | μA    |
| I <sub>SC</sub>             | Output Short Circuit Current<br>(Note 4)     | V <sub>CC</sub> = MAX, V <sub>OUT</sub> = 0.0V   |  | -40                      |                 | -100      | mA    |
| I <sub>CC</sub>             | Power Supply Current                         | V <sub>CC</sub> = MAX (Note 5)   |  |                          | 55              | 85        | mA    |

Notes: 1. For conditions shown as MIN or MAX, use the appropriate value specified under Electrical Characteristics for the applicable device type.

2. Typical limits are at V<sub>CC</sub> = 5.0V, 25°C ambient and maximum loading.

3. Actual input currents = Unit Load Current x Input Load Factor (see Loading Rules).

4. Not more than one output should be shorted at a time. Duration of the short circuit test should not exceed one second.

5. I<sub>CC</sub> is measured with all outputs open and all inputs at 4.5V.

**SWITCHING CHARACTERISTICS** (T<sub>A</sub> = 25°C)

| Parameters       | Description                                      | Test Conditions  | Min | Typ | Max  | Units |
|------------------|--|--|-----|-----|------|-------|
| t <sub>PLH</sub> | A, B, or C to Y; 4 Levels of Delay               | V <sub>CC</sub> = 5.0V, R <sub>L</sub> = 280Ω, C <sub>L</sub> = 15pF |     | 12  | 18   | ns    |
| t <sub>PHL</sub> |  |  |     | 13  | 19.5 |       |
| t <sub>PLH</sub> | A, B, or C to $\overline{W}$ ; 3 Levels of Delay |  |     | 10  | 15   | ns    |
| t <sub>PHL</sub> |  |  |     | 9   | 13.5 |       |
| t <sub>PLH</sub> | Any D to Y                                       |  |     | 8   | 12   | ns    |
| t <sub>PHL</sub> |  |  |     | 8   | 12   |       |
| t <sub>PLH</sub> | Any D to $\overline{W}$                          |  |     | 4.5 | 7    | ns    |
| t <sub>PHL</sub> |  |  |     | 4.5 | 7    |       |
| t <sub>ZH</sub>  | Output Enable to Y                               | V <sub>CC</sub> = 5.0V, R <sub>L</sub> = 280Ω, C <sub>L</sub> = 15pF |     | 13  | 19.5 | ns    |
| t <sub>ZL</sub>  |  |  |     | 14  | 21   |       |
| t <sub>ZH</sub>  | Output Enable to $\overline{W}$                  |  |     | 13  | 19.5 | ns    |
| t <sub>ZL</sub>  |  |  |     | 14  | 21   |       |
| t <sub>HZ</sub>  | Output Enable to Y                               | V <sub>CC</sub> = 5.0V, R <sub>L</sub> = 280Ω, C <sub>L</sub> = 5pF  |     | 5.5 | 8.5  | ns    |
| t <sub>LZ</sub>  |  |  |     | 9   | 14   |       |
| t <sub>HZ</sub>  | Output Enable to $\overline{W}$                  |  |     | 5.5 | 8.5  | ns    |
| t <sub>LZ</sub>  |  |  |     | 9   | 14   |       |

## FUNCTION TABLE

| INPUTS |   |   | OUTPUTS                     |               |
|--------|---|---|-----------------------------|---------------|
| SELECT |   |   | Output Control<br>$\bar{S}$ | $Y$ $\bar{W}$ |
| C      | B | A |                             |               |
| X      | X | X | H                           | Z    Z        |
| L      | L | L | L                           | $D_0$ $D_0$   |
| L      | L | H | L                           | $D_1$ $D_1$   |
| L      | H | L | L                           | $D_2$ $D_2$   |
| L      | H | H | L                           | $D_3$ $D_3$   |
| H      | L | L | L                           | $D_4$ $D_4$   |
| H      | L | H | L                           | $D_5$ $D_5$   |
| H      | H | L | L                           | $D_6$ $D_6$   |
| H      | H | H | L                           | $D_7$ $D_7$   |

H = HIGH  
L = LOW

X = Don't Care  
Z = High Impedance

$D_0$ – $D_7$  = The output will follow the HIGH-level or LOW-level of the selected input.

$\bar{D}_0$ – $\bar{D}_7$  = The output will follow the complement of the HIGH-level or LOW-level of the selected input.

## LOADING RULES (In Unit Loads)

| Input/Output | Pin No.'s | Input<br>Unit Load | Fan-out        |               |
|--------------|-----------|--------------------|----------------|---------------|
|              |           |                    | Output<br>HIGH | Output<br>LOW |
| $D_3$        | 1         | 1                  | —              | —             |
| $D_2$        | 2         | 1                  | —              | —             |
| $D_1$        | 3         | 1                  | —              | —             |
| $D_0$        | 4         | 1                  | —              | —             |
| Y            | 5         | —                  | 20             | 10            |
| $\bar{W}$    | 6         | —                  | 20             | 10            |
| $\bar{S}$    | 7         | 1                  | —              | —             |
| GND          | 8         | —                  | —              | —             |
| C            | 9         | 1                  | —              | —             |
| B            | 10        | 1                  | —              | —             |
| A            | 11        | 1                  | —              | —             |
| $D_7$        | 12        | 1                  | —              | —             |
| $D_6$        | 13        | 1                  | —              | —             |
| $D_5$        | 14        | 1                  | —              | —             |
| $D_4$        | 15        | 1                  | —              | —             |
| $V_{CC}$     | 16        | —                  | —              | —             |

A Schottky TTL Unit Load is defined as 50 $\mu$ A measured at 2.7V HIGH and –2.0mA measured at 0.5V LOW.

## DEFINITION OF FUNCTIONAL TERMS

A, B, C The three select inputs of the multiplexer.

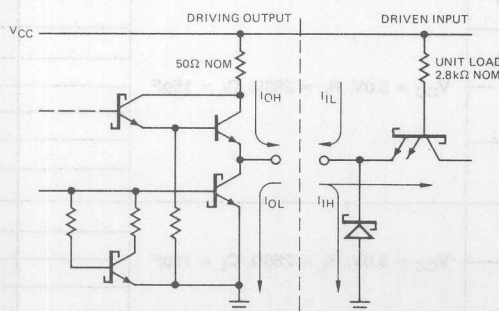
$D_0$ ,  $D_1$ ,  $D_2$ ,  $D_3$ ,

$D_4$ ,  $D_5$ ,  $D_6$ ,  $D_7$  The eight data inputs of the multiplexer.

Y The true multiplexer output.

$\bar{W}$  The complement multiplexer output.

$\bar{S}$  Output Control. HIGH on the output control (or strobe) forces both the W and Y outputs to the high-impedance (off) state.

SCHOTTKY INPUT/OUTPUT  
CURRENT INTERFACE CONDITIONS

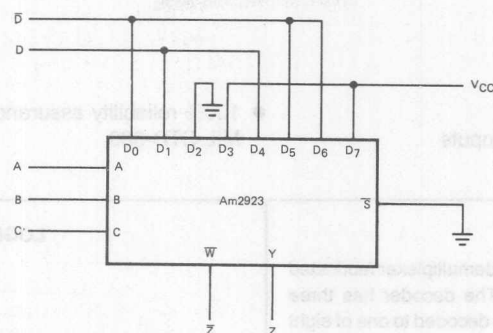
Note: Actual current flow direction shown.

BLI-072



## APPLICATIONS

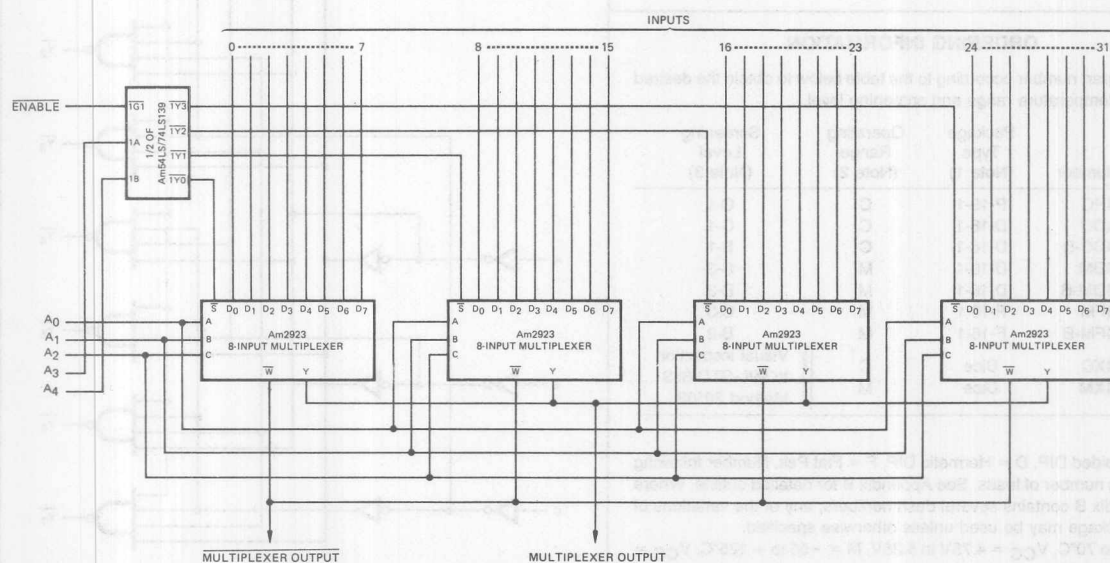
## LOGIC FUNCTION GENERATION



$$Z = \overline{A}BCD + \overline{A}BC\overline{D} + A\overline{C}D + AB + A\overline{C}\overline{D} + B\overline{C}\overline{D}$$

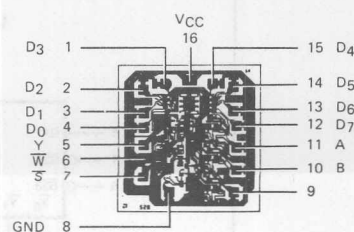
BLI-073

## 32-INPUT MULTIPLEXER



BLI-074

## Metallization and Pad Layout



DIE SIZE: 0.064" X 0.067"

# Am2924

## 3-Line to 8-Line Decoder/Demultiplexer

### Distinctive Characteristics

- Advanced Schottky technology
- Inverting and non-inverting enable inputs
- 100% reliability assurance testing in compliance with MIL-STD-883

### FUNCTIONAL DESCRIPTION

The Am2924 is a 3-line to 8-line decoder/demultiplexer fabricated using advanced Schottky technology. The decoder has three buffered select inputs A, B and C that are decoded to one of eight  $\bar{Y}$  outputs.

One active-HIGH and two active-LOW enables can be used for gating the decoder or can be used with incoming data for demultiplexing applications. When the enable input function is in the disable state, all eight  $\bar{Y}$  outputs are HIGH regardless of the A, B and C select inputs.

### ORDERING INFORMATION

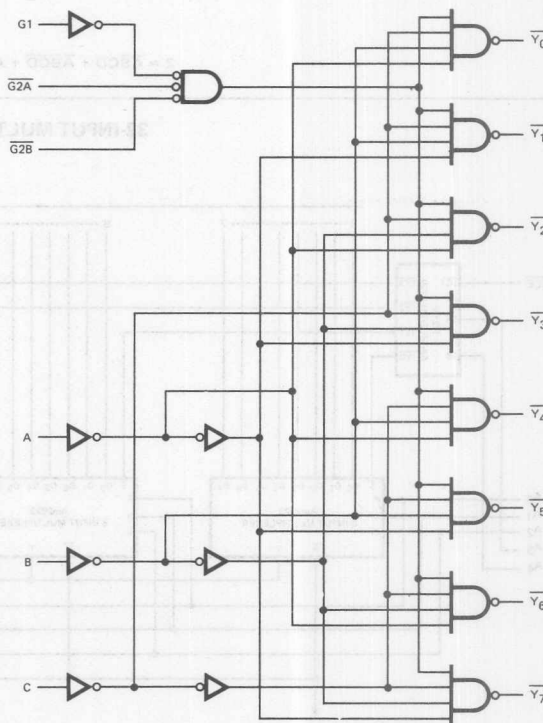
Order the part number according to the table below to obtain the desired package, temperature range and screening level.

| Order Number | Package Type<br>(Note 1) | Operating Range<br>(Note 2) | Screening Level<br>(Note 3)                          |
|--------------|--------------------------|-----------------------------|--|
| AM2924PC     | P-16-1                   | C                           | C-1  |
| AM2924DC     | D-16-1                   | C                           | C-1  |
| AM2924DC-B   | D-16-1                   | C                           | B-1  |
| AM2924DM     | D-16-1                   | M                           | C-3  |
| AM2924DM-B   | D-16-1                   | M                           | B-3  |
| AM2924FM     | F-16-1                   | M                           | C-3  |
| AM2924FM-B   | F-16-1                   | M                           | B-3  |
| AM2924XC     | Dice                     | C                           | Visual inspection<br>to MIL-STD-883<br>Method 2010B. |
| AM2924XM     | Dice                     | M                           |  |

#### Notes:

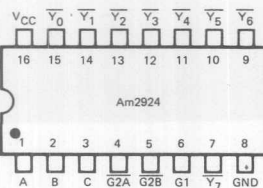
1. P = Molded DIP, D = Hermetic DIP, F = Flat Pak. Number following letter is number of leads. See Appendix B for detailed outline. Where Appendix B contains several dash numbers, any of the variations of the package may be used unless otherwise specified.
2. C = 0 to 70°C,  $V_{CC}$  = 4.75V to 5.25V, M = -55 to + 125°C,  $V_{CC}$  = 4.50V to 5.50V.
3. See Appendix A for details of screening. Levels C-1 and C-3 conform to MIL-STD-883, Class C. Level B-3 conforms to MIL-STD-883 Class B.

### LOGIC DIAGRAM



BLI-075

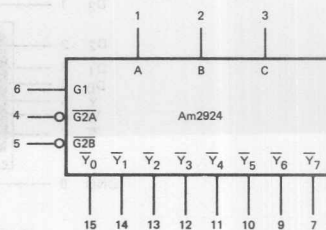
### CONNECTION DIAGRAM Top View



Note: Pin 1 is marked for orientation.

BLI-076

### LOGIC SYMBOL



$V_{CC}$  = Pin 16  
GND = Pin 8

BLI-077

**MAXIMUM RATINGS** (Above which the useful life may be impaired)

|   |                                |
|---|--------------------------------|
| Storage Temperature   | -65°C to +150°C                |
| Temperature (Ambient) Under Bias                                | -55°C to +125°C                |
| Supply Voltage to Ground Potential (Pin 16 to Pin 8) Continuous | -0.5V to +7V                   |
| DC Voltage Applied to Outputs for HIGH Output State             | -0.5V to +V <sub>CC</sub> max. |
| DC Input Voltage  | -0.5V to +5.5V                 |
| DC Output Current, Into Outputs                                 | 30mA                           |
| DC Input Current  | -30mA to +5.0mA                |

2

**ELECTRICAL CHARACTERISTICS OVER OPERATING TEMPERATURE RANGE** (Unless Otherwise Noted)

|                  |                                  |                                    |              |              |
|------------------|----------------------------------|------------------------------------|--------------|--------------|
| Am2924PC, DC, XC | T <sub>A</sub> = 0°C to +70°C    | V <sub>CC</sub> = 5.0V ±5% (COM'L) | MIN. = 4.75V | MAX. = 5.25V |
| Am2924DM, FM, XM | T <sub>A</sub> = -55°C to +125°C | V <sub>CC</sub> = 5.0V ±10% (MIL)  | MIN. = 4.5V  | MAX. = 5.5V  |

| Parameters                  | Description                  | Test Conditions (Note 1)   | Min.                       | Typ.<br>(Note 2) | Max. | Units |
|-----------------------------|------------------------------|--|----------------------------|------------------|------|-------|
| V <sub>OH</sub>             | Output HIGH Voltage          | V <sub>CC</sub> = MIN., I <sub>OH</sub> = -1mA<br>V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub> | MIL<br>2.5<br>COM'L<br>2.7 | 3.4              |      | Volts |
| V <sub>OL</sub>             | Output LOW Voltage           | V <sub>CC</sub> = MIN., I <sub>OL</sub> = 20mA<br>V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub> |                            |                  | 0.5  | Volts |
| V <sub>IH</sub>             | Input HIGH Level             | Guaranteed input logical HIGH voltage for all inputs   | 2.0                        |                  |      | Volts |
| V <sub>IL</sub>             | Input LOW Level              | Guaranteed input logical LOW voltage for all inputs  |                            |                  | 0.8  | Volts |
| V <sub>I</sub>              | Input Clamp Voltage          | V <sub>CC</sub> = MIN., I <sub>IN</sub> = -18mA  |                            |                  | -1.2 | Volts |
| I <sub>IL</sub><br>(Note 3) | Input LOW Current            | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 0.5V   |                            |                  | -2   | mA    |
| I <sub>IH</sub><br>(Note 3) | Input HIGH Current           | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 2.7V   |                            |                  | 50   | μA    |
| I <sub>I</sub>              | Input HIGH Current           | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 5.5V   |                            |                  | 1.0  | mA    |
| I <sub>SC</sub><br>(Note 4) | Output Short Circuit Current | V <sub>CC</sub> = MAX., V <sub>OUT</sub> = 0.0V  | -40                        |                  | -100 | mA    |
| I <sub>CC</sub>             | Power Supply Current         | V <sub>CC</sub> = MAX. (Note 5)  |                            | 49               | 74   | mA    |

Notes: 1. For conditions shown as MIN. or MAX., use the appropriate value specified under Electrical Characteristics for the applicable device type.

2. Typical limits are at V<sub>CC</sub> = 5.0 V, 25°C ambient and maximum loading.

3. Actual input currents = Unit Load Current x Input Load Factor (See Loading Rules).

4. Not more than one output should be shorted at a time. Duration of the short circuit test should not exceed one second.

5. Outputs enabled and open.

**Switching Characteristics** (T<sub>A</sub> = +25°C)

| Parameters       | Description                           | Test Conditions  | Min. | Typ. | Max. | Units |
|------------------|---------------------------------------|--|------|------|------|-------|
| t <sub>PLH</sub> | Two Level Delay<br>Select to Output   | V <sub>CC</sub> = 5V, C <sub>L</sub> = 15pF, R <sub>L</sub> = 280Ω |      | 4.5  | 7    | ns    |
| t <sub>PHL</sub> |                                       |  |      | 7    | 10.5 |       |
| t <sub>PLH</sub> | Three Level Delay<br>Select to Output |  |      | 7.5  | 12   | ns    |
| t <sub>PHL</sub> |                                       |  |      | 8    | 12   |       |
| t <sub>PLH</sub> | G2A or G2B<br>to Output               |  |      | 5    | 8    | ns    |
| t <sub>PHL</sub> |                                       |  |      | 7    | 11   |       |
| t <sub>PLH</sub> | G1 to Output                          |  |      | 7    | 11   | ns    |
| t <sub>PHL</sub> |                                       |  |      | 7    | 11   |       |

# FUNCTION TABLE

| Inputs |     |     |        |   | Outputs |                |                |                |                |                |                |                |                |
|--------|-----|-----|--------|---|---------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| Enable |     |     | Select |   |         |                |                |                |                |                |                |                |                |
| G1     | G2A | G2B | C      | B | A       | Y <sub>0</sub> | Y <sub>1</sub> | Y <sub>2</sub> | Y <sub>3</sub> | Y <sub>4</sub> | Y <sub>5</sub> | Y <sub>6</sub> | Y <sub>7</sub> |
| L      | X   | X   | X      | X | X       | H              | H              | H              | H              | H              | H              | H              | H              |
| X      | H   | X   | X      | X | X       | H              | H              | H              | H              | H              | H              | H              | H              |
| X      | X   | H   | X      | X | X       | H              | H              | H              | H              | H              | H              | H              | H              |
| H      | L   | L   | L      | L | L       | L              | H              | H              | H              | H              | H              | H              | H              |
| H      | L   | L   | L      | L | H       | H              | L              | H              | H              | H              | H              | H              | H              |
| H      | L   | L   | L      | H | L       | H              | H              | L              | H              | H              | H              | H              | H              |
| H      | L   | L   | L      | H | H       | H              | H              | L              | H              | H              | H              | H              | H              |
| H      | L   | L   | H      | L | L       | H              | H              | H              | L              | H              | H              | H              | H              |
| H      | L   | L   | H      | L | H       | H              | H              | H              | H              | L              | H              | H              | H              |
| H      | L   | L   | H      | H | L       | H              | H              | H              | H              | H              | L              | H              | H              |
| H      | L   | L   | H      | H | H       | H              | H              | H              | H              | H              | H              | L              | H              |

H = HIGH

L = LOW

X = Don't care

# LOADING RULES (in mA)

| Input/Output     | Pin No.'s | Unit Load | Fan-out     |            |
|------------------|-----------|-----------|-------------|------------|
|                  |           |           | Output HIGH | Output LOW |
| A                | 1         | 1         | —           | —          |
| B                | 2         | 1         | —           | —          |
| C                | 3         | 1         | —           | —          |
| G2A              | 4         | 1         | —           | —          |
| G2B              | 5         | 1         | —           | —          |
| G1               | 6         | 1         | —           | —          |
| $\overline{Y_7}$ | 7         | —         | 20          | 10         |
| GND              | 8         | —         | —           | —          |
| $\overline{Y_6}$ | 9         | —         | 20          | 10         |
| $\overline{Y_5}$ | 10        | —         | 20          | 10         |
| $\overline{Y_4}$ | 11        | —         | 20          | 10         |
| $\overline{Y_3}$ | 12        | —         | 20          | 10         |
| $\overline{Y_2}$ | 13        | —         | 20          | 10         |
| $\overline{Y_1}$ | 14        | —         | 20          | 10         |
| $\overline{Y_0}$ | 15        | —         | 20          | 10         |
| V <sub>CC</sub>  | 16        | —         | —           | —          |

A Schottky TTL Unit Load is defined as 50 $\mu$ A measured at 2.7V HIGH and —2.0mA measured at 0.5V LOW.

## DEFINITION OF FUNCTIONAL TERMS:

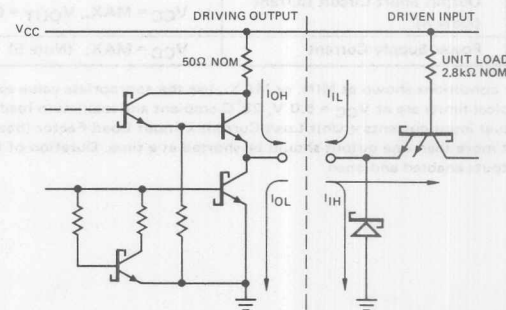
A, B, C Select. The three select inputs to the decoder.

G1 The active-HIGH enable input. A LOW on the G1 input forces all  $\overline{Y}$  outputs HIGH regardless of any other inputs.

G2A, G2B The active-LOW enable input. A HIGH on either the G2A or G2B input forces all  $\overline{Y}$  outputs HIGH regardless of any other inputs.

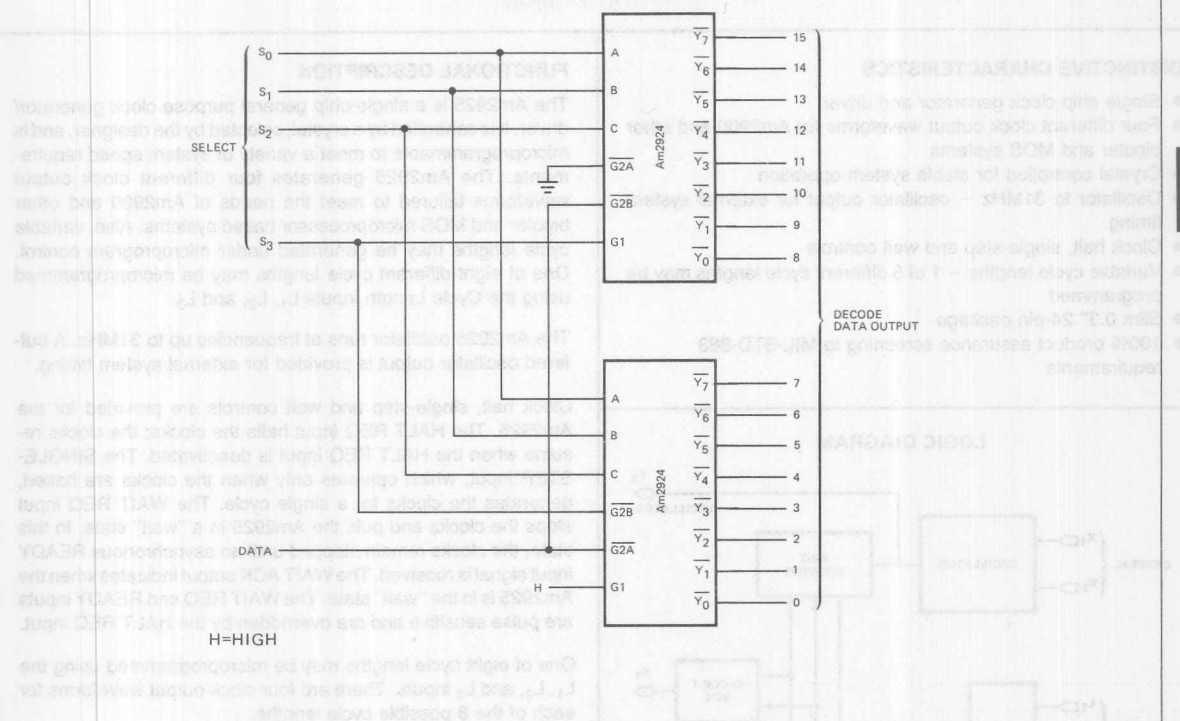
$\overline{Y_0}$ ,  $\overline{Y_1}$ ,  $\overline{Y_2}$ ,  $\overline{Y_3}$ ,  $\overline{Y_4}$ ,  $\overline{Y_5}$ ,  $\overline{Y_6}$ ,  $\overline{Y_7}$  The eight decoder outputs.

## SCHOTTKY INPUT/OUTPUT CURRENT INTERFACE CONDITIONS



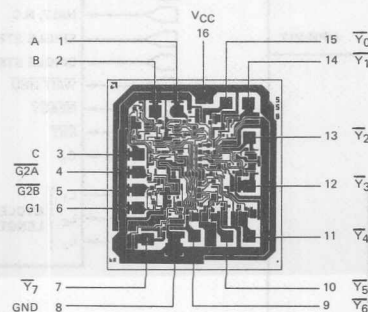
Note: Actual current flow direction shown.

## APPLICATION



## ONE-OF-SIXTEEN DEMULTIPLEXER

## Metallization and Pad Layout



DIE SIZE 0.065"X0.070"



# Am2925

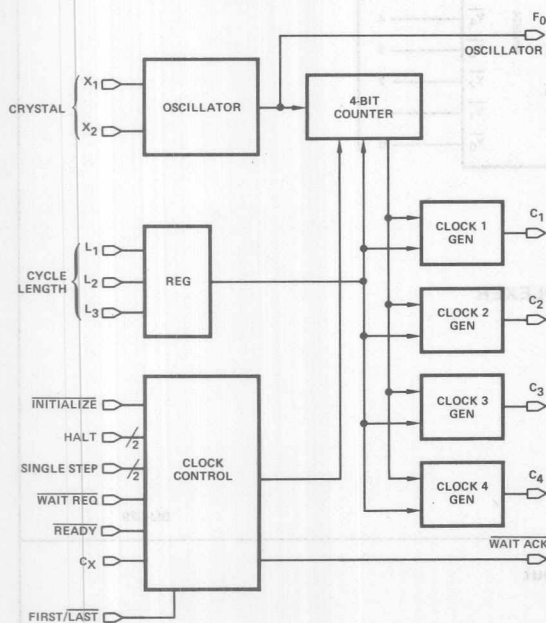
## System Clock Generator and Driver

### ADVANCED INFORMATION

#### DISTINCTIVE CHARACTERISTICS

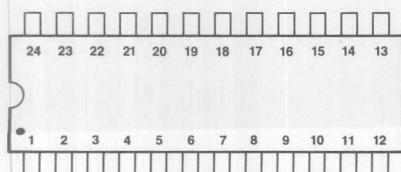
- Single chip clock generator and driver
- Four different clock output waveforms for Am2900 and other bipolar and MOS systems
- Crystal controlled for stable system operation
- Oscillator to 31MHz – oscillator output for external system timing
- Clock halt, single-step and wait controls
- Variable cycle lengths – 1 of 8 different cycle lengths may be programmed
- Slim 0.3" 24-pin package
- 100% product assurance screening to MIL-STD-883 requirements

#### LOGIC DIAGRAM



MPR-217

#### CONNECTION DIAGRAM Top View



Note: Pin 1 is marked for orientation.

MPR-219

#### FUNCTIONAL DESCRIPTION

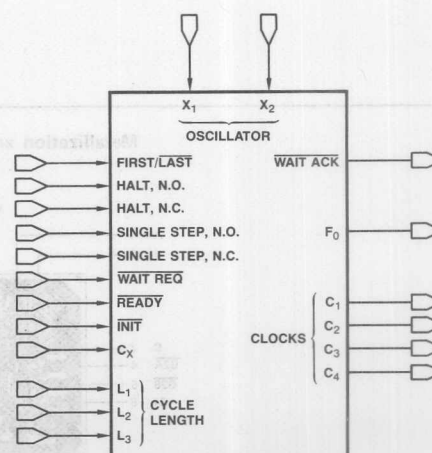
The Am2925 is a single-chip general purpose clock generator/driver. It is controlled by a crystal, selected by the designer, and is microprogrammable to meet a variety of system speed requirements. The Am2925 generates four different clock output waveforms tailored to meet the needs of Am2900 and other bipolar and MOS microprocessor based systems. Also, variable cycle lengths may be generated under microprogram control. One of eight different cycle lengths may be microprogrammed using the Cycle Length inputs L<sub>1</sub>, L<sub>2</sub>, and L<sub>3</sub>.

The Am2925 oscillator runs at frequencies up to 31MHz. A buffered oscillator output is provided for external system timing.

Clock halt, single-step and wait controls are provided for the Am2925. The HALT REQ input halts the clocks; the clocks resume when the HALT REQ input is deactivated. The SINGLE-STEP input, which operates only when the clocks are halted, generates the clocks for a single cycle. The WAIT REQ input stops the clocks and puts the Am2925 in a "wait" state. In this state, the clocks remain stopped until an asynchronous READY input signal is received. The WAIT ACK output indicates when the Am2925 is in the "wait" state. The WAIT REQ and READY inputs are pulse sensitive and are overridden by the HALT REQ input.

One of eight cycle lengths may be microprogrammed using the L<sub>1</sub>, L<sub>2</sub>, and L<sub>3</sub> inputs. There are four clock output waveforms for each of the 8 possible cycle lengths.

#### LOGIC SYMBOL



MPR-218

The Am2925 is scheduled for introduction in 2Q '80.

# Am2926 • Am2929

## Schottky Three-State Quad Bus Driver/Receiver

### Distinctive Characteristics

- Advanced Schottky technology
- 48mA driver sink current
- 3-state outputs on driver and receiver
- PNP inputs
- Am2926 has inverting outputs
- Am2929 has non-inverting outputs
- Driver propagation delay – 14ns max for Am2926; 17ns max for Am2929
- Receiver propagation delay – 14ns max for Am2926; 17ns max for Am2929
- 100% reliability assurance testing in compliance with MIL-STD-883

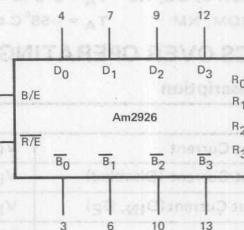
### FUNCTIONAL DESCRIPTION

The Am2926 and Am2929 are high speed bus transceivers consisting of four bus drivers with three-state outputs and four bus receivers, also with three-state outputs. Each driver output is internally connected to a receiver input. Both the drivers and receivers have PNP inputs.

One buffered common "bus enable" input is connected to the four drivers and another buffered common "receiver enable" input is connected to the receivers. A LOW on the bus enable (B/E) input forces the four driver outputs to the high-impedance state. A HIGH on the bus enable allows input data to be transferred onto the data bus.

A HIGH on the receiver enable (R/E) input forces the four receiver outputs to the high-impedance state while a LOW on the receiver enable input allows the received data to be transferred to the output. The complementary design of the bus enable and receiver enable inputs allows these control inputs to be connected together externally such that a single transmit/receive function is derived.

### LOGIC SYMBOL

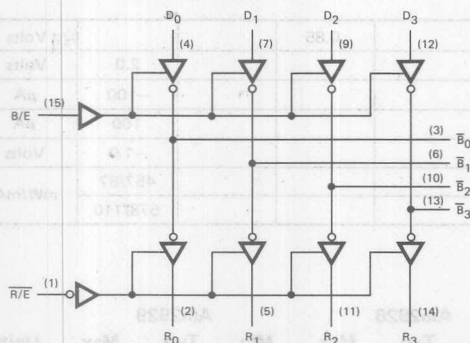


VCC = Pin 16  
GND = Pin 8

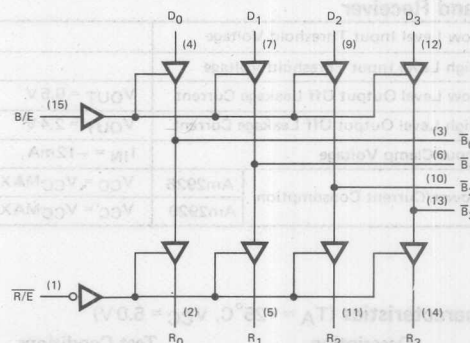
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### LOGIC DIAGRAMS

**Am2926**  
**Inverting Output (3-State)**



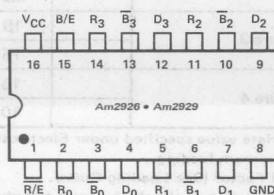
**Am2929**  
**Non-Inverting Output (3-State)**



BLI-080

### CONNECTION DIAGRAM

#### Top View



BLI-081

# Am2926 • Am2929

## MAXIMUM RATINGS (Above which the useful life may be impaired)

|   |                                |
|---|--------------------------------|
| Storage Temperature   | −65°C to +150°C                |
| Temperature (Ambient) Under Bias                                | −55°C to +125°C                |
| Supply Voltage to Ground Potential (Pin 16 to Pin 8) Continuous | −0.5V to +7V                   |
| DC Voltage Applied to Outputs for HIGH Output State             | −0.5V to +V <sub>CC</sub> max. |
| DC Input Voltage  | −0.5V to +5.5V                 |
| DC Output Current, Into Outputs (Receiver)                      | 30mA                           |
| DC Output Current, Into Outputs (BUS)                           | 80mA                           |
| DC Input Current  | −30mA to +5.0mA                |

## ELECTRICAL CHARACTERISTICS OVER OPERATING TEMPERATURE RANGE

The Following Conditions Apply Unless Otherwise Noted:

|                  |                  |  |               |               |
|------------------|------------------|--|---------------|---------------|
| Am2926PC, DC, XC | Am2929PC, DC, XC | T <sub>A</sub> = 0°C to +75°C (COM'L)  | MIN. = 4.75 V | MAX. = 5.25 V |
| Am2929DM, XM     | Am2926DM, XM     | T <sub>A</sub> = −55°C to +125°C (MIL) | MIN. = 4.50 V | MAX. = 5.50 V |

## DC CHARACTERISTICS OVER OPERATING TEMPERATURE RANGE

| Parameters                           | Description  | Test Conditions (Note 1)   | Min. | Typ.<br>(Note 2) | Max.    | Units |
|--------------------------------------|--|--|------|------------------|---------|-------|
| <b>Driver</b>                        |  |  |      |                  |         |       |
| I <sub>IL</sub>                      | Low Level Input Current                                      | V <sub>IN</sub> = 0.4 V  |      |                  | −200    | μA    |
| I <sub>IL</sub>                      | Low Level Input Current (Disabled)                           | V <sub>IN</sub> = 0.4 V  |      |                  | −25     | μA    |
| I <sub>IH</sub>                      | High Level Input Current (D <sub>IN</sub> , D <sub>E</sub> ) | V <sub>IN</sub> = V <sub>CC</sub> MAX.                                     |      |                  | 25      | μA    |
| V <sub>OL</sub>                      | Low Level Output Voltage                                     | I <sub>OUT</sub> = 48 mA (Note 5)  |      |                  | 0.5     | Volts |
| V <sub>OH</sub>                      | High Level Output Voltage                                    | I <sub>OUT</sub> = −10 mA, V <sub>CC</sub> = V <sub>CC</sub> MIN. (Note 6) | 2.4  |                  |         | Volts |
| I <sub>OS</sub>                      | Short Circuit Output Current                                 | V <sub>OUT</sub> = 0 V, V <sub>CC</sub> = V <sub>CC</sub> MAX. (Note 4)    | −50  |                  | −150    | mA    |
| <b>Receiver</b>                      |  |  |      |                  |         |       |
| I <sub>IL</sub>                      | Low Level Input Current                                      | V <sub>IN</sub> = 0.4 V  |      |                  | −200    | μA    |
| I <sub>IH</sub>                      | High Level Input Current (R <sub>E</sub> )                   | V <sub>IN</sub> = V <sub>CC</sub> MAX.                                     |      |                  | 25      | μA    |
| V <sub>OL</sub>                      | Low Level Output Voltage                                     | I <sub>OUT</sub> = 20 mA (Note 5)  |      |                  | 0.5     | Volts |
| V <sub>OH</sub>                      | High Level Output Voltage                                    | I <sub>OUT</sub> = −100 μA, V <sub>CC</sub> = 5.0 V                        | 3.5  |                  |         | Volts |
|                                      |  | I <sub>OUT</sub> = −2.0 mA (Note 6)  | 2.4  |                  |         |       |
| I <sub>OS</sub>                      | Short Circuit Output Current                                 | V <sub>OUT</sub> = 0 V, V <sub>CC</sub> = V <sub>CC</sub> MAX.             | −30  |                  | −75     | mA    |
| <b>Both Driver and Receiver</b>      |  |  |      |                  |         |       |
| V <sub>TL</sub>                      | Low Level Input Threshold Voltage                            |  | 0.85 |                  |         | Volts |
| V <sub>TH</sub>                      | High Level Input Threshold Voltage                           |  |      |                  | 2.0     | Volts |
| I <sub>O</sub>                       | Low Level Output Off Leakage Current                         | V <sub>OUT</sub> = 0.5 V   |      |                  | −100    | μA    |
|                                      | High Level Output Off Leakage Current                        | V <sub>OUT</sub> = 2.4 V   |      |                  | 100     | μA    |
| V <sub>I</sub>                       | Input Clamp Voltage  | I <sub>IN</sub> = −12 mA   |      |                  | −1.0    | Volts |
| P <sub>WR</sub> /<br>I <sub>CC</sub> | Power/Current Consumption                                    | Am2926 V <sub>CC</sub> = V <sub>CC</sub> MAX.                              |      |                  | 457/87  | mW/mA |
|                                      |  | Am2929 V <sub>CC</sub> = V <sub>CC</sub> MAX.                              |      |                  | 578/110 |       |

## Switching Characteristics (T<sub>A</sub> = +25°C, V<sub>CC</sub> = 5.0 V)

| Parameters       | Description                        | Test Conditions | Am2926 |      |      | Am2929 |      |      | Units |
|------------------|------------------------------------|-----------------|--------|------|------|--------|------|------|-------|
|                  |                                    |                 | Min.   | Typ. | Max. | Min.   | Typ. | Max. |       |
| t <sub>PLH</sub> | Driver Input to Bus                | Figure 1        |        | 10   | 14   |        | 13   | 17   | ns    |
| t <sub>PHL</sub> |                                    |                 |        | 10   | 14   |        | 13   | 17   |       |
| t <sub>PLH</sub> | Bus to Receiver Output             | Figure 2        |        | 9.0  | 14   |        | 12   | 17   | ns    |
| t <sub>PHL</sub> |                                    |                 |        | 6.0  | 14   |        | 9.0  | 17   |       |
| t <sub>ZL</sub>  | Driver Enable to Bus               | Figure 3        |        | 19   | 25   |        | 21   | 28   | ns    |
| t <sub>LZ</sub>  |                                    |                 |        | 15   | 20   |        | 18   | 23   |       |
| t <sub>ZL</sub>  | Receiver Enable to Receiver Output | Figure 4        |        | 15   | 20   |        | 18   | 23   | ns    |
| t <sub>LZ</sub>  |                                    |                 |        | 10   | 15   |        | 13   | 18   |       |

Notes: 1. For conditions shown as MIN. or MAX., use the appropriate value specified under Electrical Characteristics for the applicable device type.

2. Typical limits are at V<sub>CC</sub> = 5.0 V, 25°C ambient and maximum loading.

3. Actual input currents = Unit Load Current x Input Load Factor (See Loading Rules).

4. Not more than one output should be shorted at a time. Duration of the short circuit test should not exceed one second.

5. Output sink current is supplied through a resistor to V<sub>CC</sub>.

6. Measurements apply to each output and the associated data input independently.

## DEFINITION OF FUNCTIONAL TERMS

$D_0, D_1, D_2, D_3$  The four driver inputs.

$\overline{B_0}, \overline{B_1}, \overline{B_2}, \overline{B_3}$  The four driver outputs and receiver inputs (data is inverted).

$R_0, R_1, R_2, R_3$  The four receiver outputs. Data from the bus is inverted while data from the driver inputs is non-inverted.

$B/E$  Bus enable input. When the bus enable input is LOW, the four driver outputs are in the high-impedance state.

$\overline{R/E}$  Receiver enable input. When the receiver enable input is HIGH, the four receiver outputs are in the high-impedance state.

## LOADING RULES (In Unit Loads)

| Input/Output     | Pin No.'s | LOW Input Unit Load | Fan-out Output HIGH | Output LOW |
|------------------|-----------|---------------------|---------------------|------------|
| $\overline{R/E}$ | 1         | 1/8                 | —                   | —          |
| $R_0$            | 2         | —                   | 50                  | 10         |
| $\overline{B_0}$ | 3         | 1/16                | 250                 | 25         |
| $D_0$            | 4         | 1/8                 | —                   | —          |
| $R_1$            | 5         | —                   | 50                  | 10         |
| $\overline{B_1}$ | 6         | 1/16                | 250                 | 25         |
| $D_1$            | 7         | 1/8                 | —                   | —          |
| GND              | 8         | —                   | —                   | —          |
| $D_2$            | 9         | 1/8                 | —                   | —          |
| $\overline{B_2}$ | 10        | 1/16                | 250                 | 25         |
| $R_2$            | 11        | —                   | 50                  | 10         |
| $D_3$            | 12        | 1/8                 | —                   | —          |
| $\overline{B_3}$ | 13        | 1/16                | 250                 | 25         |
| $R_3$            | 14        | —                   | 50                  | 10         |
| $B/E$            | 15        | 1/8                 | —                   | —          |
| $V_{CC}$         | 16        | —                   | —                   | —          |

A TTL Unit Load is defined as  $-1.6\text{mA}$  measured at  $0.4\text{V}$  LOW and  $40\mu\text{A}$  measured at  $2.4\text{V}$  HIGH.

## DRIVER FUNCTION TABLE

| INPUTS |       | Am2926 OUTPUT    | Am2929 OUTPUT    |
|--------|-------|------------------|------------------|
| $B/E$  | $D_i$ | $\overline{B_i}$ | $\overline{B_i}$ |
| L      | X     | Z                | Z                |
| H      | L     | H                | L                |
| H      | H     | L                | H                |

L = LOW

H = HIGH

$i = 0, 1, 2, \text{ or } 3$

X = Don't Care

Z = High Impedance

## RECEIVER FUNCTION TABLE

| INPUTS           |                  | Am2926 OUTPUT | Am2929 OUTPUT |
|------------------|------------------|---------------|---------------|
| $\overline{R/E}$ | $\overline{B_i}$ | $R_i$         | $R_i$         |
| H                | X                | Z             | Z             |
| L                | L                | H             | L             |
| L                | H                | L             | H             |

L = LOW

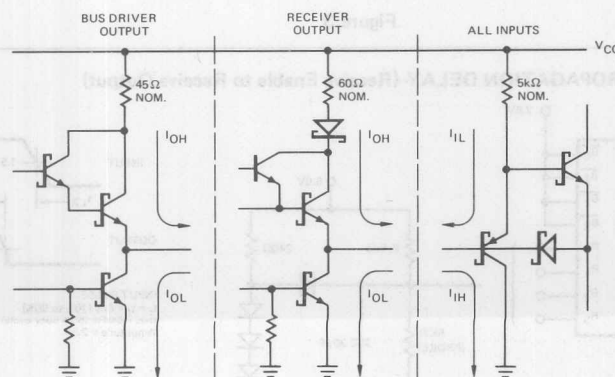
H = HIGH

$i = 0, 1, 2, \text{ or } 3$

X = Don't Care

Z = High Impedance

## INPUT/OUTPUT CURRENT INTERFACE CONDITIONS



Note: Actual current flow direction shown.

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## AC TEST CIRCUITS AND WAVEFORMS

## PROPAGATION DELAY (Data In to Bus)

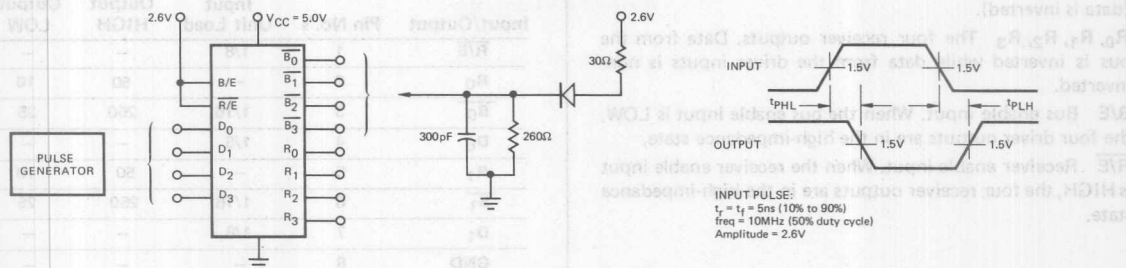


Figure 1

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## PROPAGATION DELAY (Bus to Receiver Out)

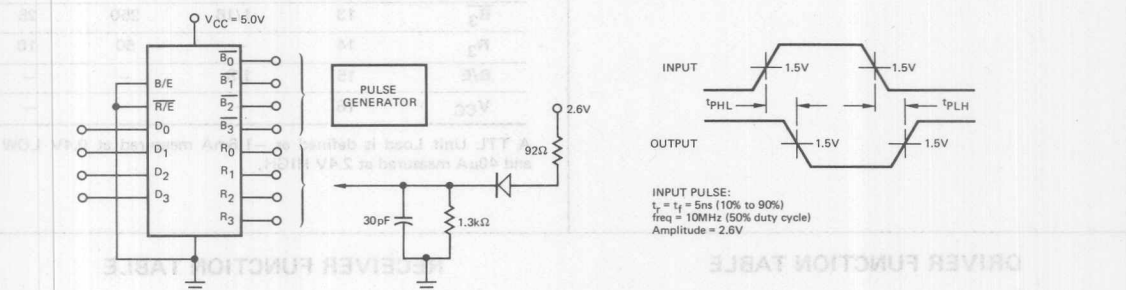


Figure 2

BLI-084

## PROPAGATION DELAY (Bus Enable to Bus Output)

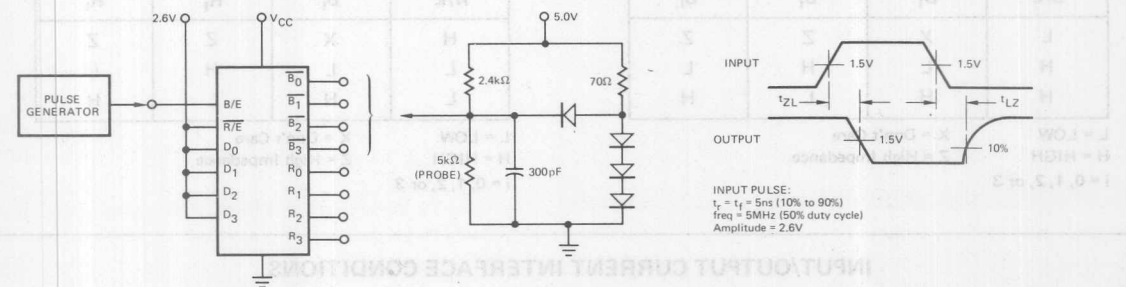


Figure 3

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## PROPAGATION DELAY (Receive Enable to Receive Output)

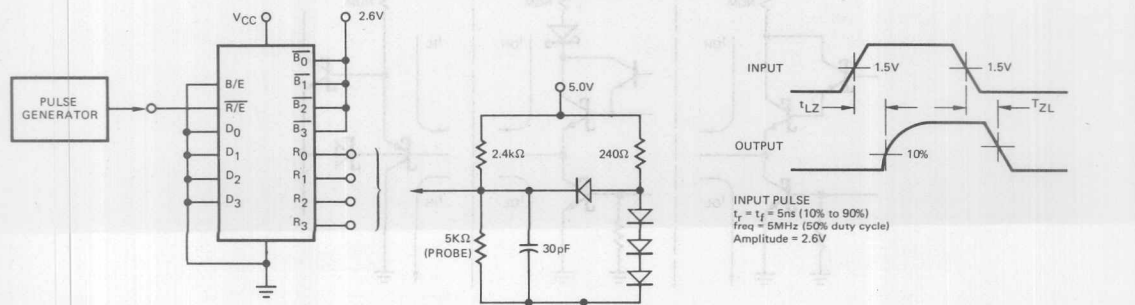
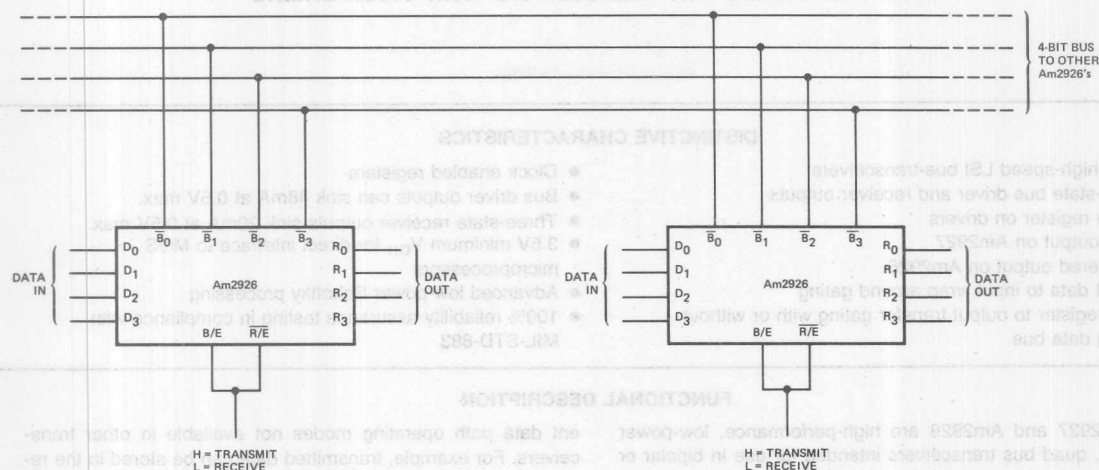


Figure 4

BLI-086



## APPLICATION



2

BLI-087

## ORDERING INFORMATION

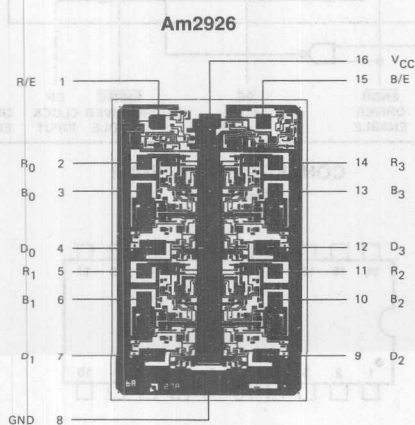
Order the part number according to the table below to obtain the desired package, temperature range, and screening level.

| Am2926<br>Order Number | Am2929<br>Order Number | Package Type<br>(Note 1) | Operating Range<br>(Note 2) | Screening Level<br>(Note 3)                           |
|------------------------|------------------------|--------------------------|-----------------------------|---|
| AM2929PC               | AM2929PC               | P-16-1                   | C                           | C-1   |
| AM2929DC               | AM2929DC               | D-16-1                   | C                           | C-1   |
| AM2929DC-B             | AM2929DC-B             | D-16-1                   | C                           | B-1   |
| AM2926DM               |                        | D-16-1                   | M                           | C-3   |
| AM2926DM-B             |                        | D-16-1                   | M                           | B-3   |
| AM2926XC               | AM2929XC               | Dice                     | C                           | Visual inspection<br>to MIL-STD-883<br>Method 2010 B. |
| AM2926XM               |                        | Dice                     | M                           |   |

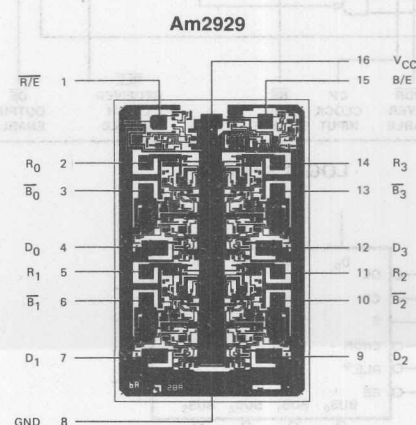
## Notes:

1. P = Molded DIP, D = Hermetic DIP, F = Flat Pak. Number following letter is number of leads. See Appendix B for detailed outline. Where Appendix B contains several dash numbers, any of the variations of the package may be used unless otherwise specified.
2. C = 0 to 70°C, V<sub>CC</sub> = 4.75V to 5.25V, M = -55 to + 125°C, V<sub>CC</sub> = 4.50V to 5.50V.
3. See Appendix A for details of screening. Levels C-1 and C-3 conform to MIL-STD-883, Class C. Level B-3 conforms to MIL-STD-883, Class B.

## Metallization and Pad Layouts



DIE SIZE 0.058" X 0.091"



DIE SIZE 0.058" X 0.091"

# Am2927 • Am2928

## Quad Three-State Bus Transceivers With Clock Enable

### DISTINCTIVE CHARACTERISTICS

- Quad high-speed LSI bus-transceivers
- Three-state bus driver and receiver outputs
- D-type register on drivers
- Latch output on Am2927
- Registered output on Am2928
- Output data to input wrap around gating
- Input register to output transfer gating with or without driving data bus
- Clock enabled registers
- Bus driver outputs can sink 48mA at 0.5V max.
- Three-state receiver outputs sink 20mA at 0.5V max.
- 3.5V minimum  $V_{OH}$  for direct interface to MOS microprocessors
- Advanced low-power Schottky processing
- 100% reliability assurance testing in compliance with MIL-STD-883

### FUNCTIONAL DESCRIPTION

The Am2927 and Am2928 are high-performance, low-power Schottky, quad bus transceivers intended for use in bipolar or MOS microprocessor system applications.

Both devices feature register enable lines which function as clock enables without introducing gate delay in the clock inputs. The four transceivers share common enables, clock, select and three-state control lines.

The Am2927 consists of four D-type edge-triggered flip-flops. Each flip-flop output is connected to a three-state data bus driver and separately to the input of a corresponding receiver latch input. The receiver latch can select input from the driver or the data bus. The select line determines the source of input data for the bus driver choosing between input data or data recirculated from the receiver output. The receiver output also has a three-state output buffer.

The combination of the select input,  $S$ , the driver input enable,  $ENDR$ , and the receiver latch enable,  $RLE$ , provide seven differ-

ent data path operating modes not available in other transceivers. For example, transmitted data can be stored in the receiver for subsequent retransmission. Also, received data can be output to the system and simultaneously fed back to the driver input.

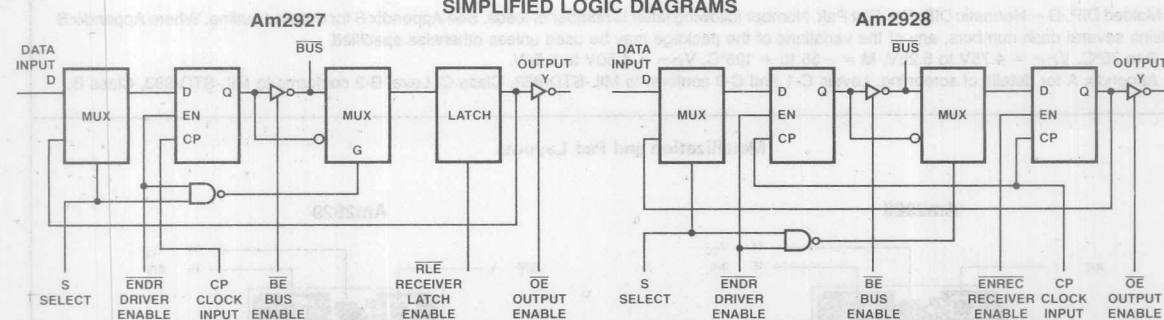
The Am2928 is similar to the Am2927, but with a D-type edge-triggered register in the receiver and a receiver enable,  $ENREC$ , which functions as a common clock enable.

Data from each D input is inverted at the bus output. Likewise, data at the bus input is inverted at the receiver output.

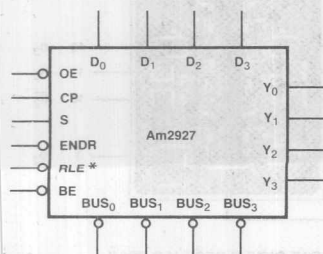
All three-state controls and enable lines are active low (the Am2927 receiver latch is transparent when  $RLE$  is LOW). The select input,  $S$ , determines whether the enabled driver input accepts data from the data input,  $D$ , or from the corresponding receiver output,  $Y$ . Similarly, the select line determines whether the receiver accepts input data from the data bus, or the driver output.

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### SIMPLIFIED LOGIC DIAGRAMS



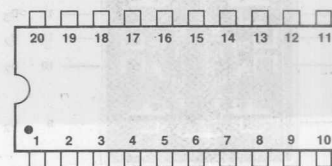
### LOGIC SYMBOL



\*ENREC for Am2928

BLI-089

### CONNECTION DIAGRAM Top View

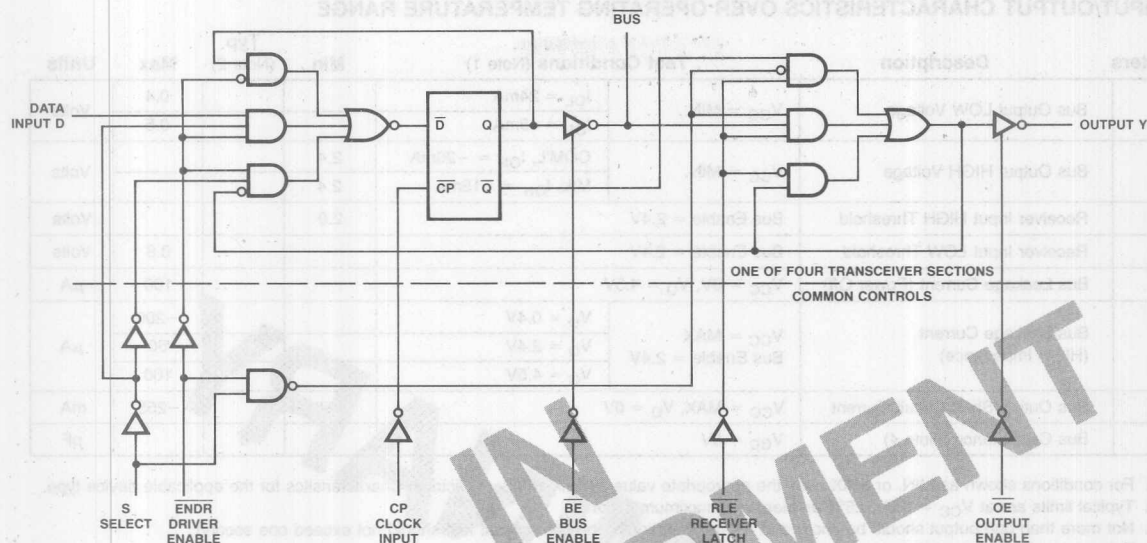


Note: Pin 1 is marked for orientation.

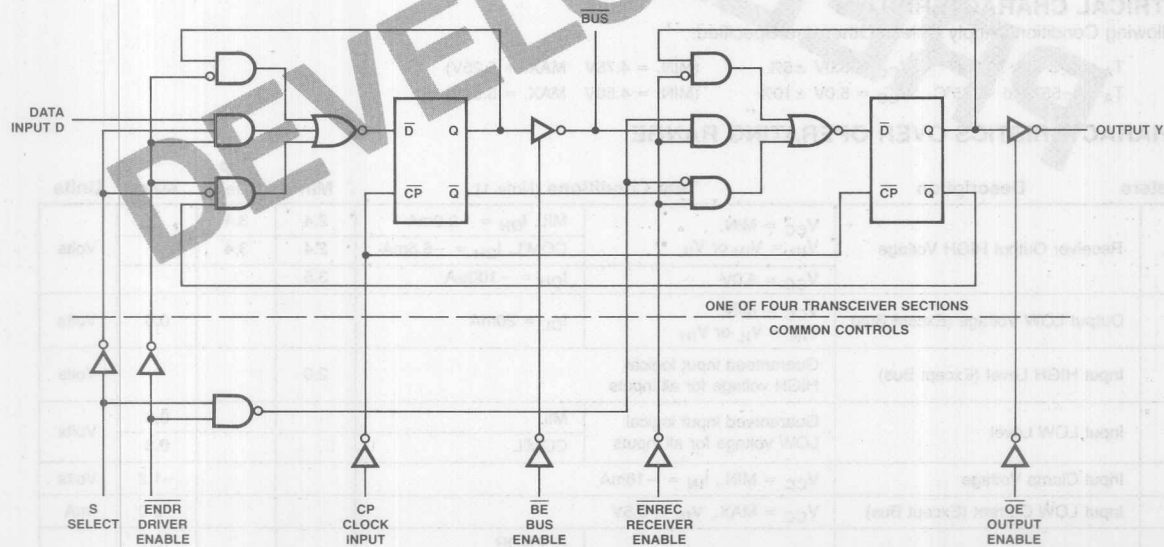
BLI-090

## DETAILED LOGIC DIAGRAMS

Am2927



Am2928



## MAXIMUM RATINGS (Above which the useful life may be impaired)

|   |                                 |
|---|---------------------------------|
| Storage Temperature                                 | -65 to +150°C                   |
| Temperature (Ambient) Under Bias                    | -55 to +125°C                   |
| Supply Voltage to Ground Potential                  | -0.5 to +7V                     |
| DC Voltage Applied to Outputs for HIGH Output State | -0.5 V to +V <sub>CC</sub> max. |
| DC Input Voltage                                    | -0.5 to +5.5V                   |
| DC Output Current, Into Outputs (Except BUS)        | 30 mA                           |
| DC Output Current, Into Bus                         | 100 mA                          |
| DC Input Current                                    | -30 to +5.0mA                   |

# Am2927 • Am2928

## ELECTRICAL CHARACTERISTICS

The Following Conditions Apply Unless Otherwise Specified:

|       |  |                                 |                             |
|-------|--|---------------------------------|-----------------------------|
| COM'L | $T_A = 0^\circ\text{C to } +70^\circ\text{C}$    | $V_{CC} = 5.0\text{V} \pm 5\%$  | (MIN. = 4.75V MAX. = 5.25V) |
| MIL   | $T_A = -55^\circ\text{C to } +125^\circ\text{C}$ | $V_{CC} = 5.0\text{V} \pm 10\%$ | (MIN. = 4.50V MAX. = 5.50V) |

## BUS INPUT/OUTPUT CHARACTERISTICS OVER OPERATING TEMPERATURE RANGE

| Parameters | Description                             | Test Conditions (Note 1)                   | Min                            | Typ<br>(Note 2) | Max  | Units         |
|------------|---|--|--------------------------------|-----------------|------|---------------|
| $V_{OL}$   | Bus Output LOW Voltage                  | $V_{CC} = \text{MIN.}$                     | $I_{OL} = 24\text{mA}$         |                 | 0.4  | Volts         |
|            |   |  | $I_{OL} = 48\text{mA}$         |                 | 0.5  |               |
| $V_{OH}$   | Bus Output HIGH Voltage                 | $V_{CC} = \text{MIN.}$                     | COM'L, $I_{OH} = -20\text{mA}$ | 2.4             |      | Volts         |
|            |   |  | MIL, $I_{OH} = -15\text{mA}$   | 2.4             |      |               |
| $V_{IH}$   | Receiver Input HIGH Threshold           | Bus Enable = 2.4V                          | 2.0                            |                 |      | Volts         |
| $V_{IL}$   | Receiver Input LOW Threshold            | Bus Enable = 2.4V                          |                                |                 | 0.8  | Volts         |
| $I_{OFF}$  | Bus Leakage Current (Power Off)         | $V_{CC} = 0\text{V}, V_O = 4.5\text{V}$    |                                |                 | 100  | $\mu\text{A}$ |
| $I_O$      | Bus Leakage Current<br>(HIGH Impedance) | $V_{CC} = \text{MAX}$<br>Bus Enable = 2.4V | $V_O = 0.4\text{V}$            |                 | -200 | $\mu\text{A}$ |
|            |   |  | $V_O = 2.4\text{V}$            |                 | 50   |               |
|            |   |  | $V_O = 4.5\text{V}$            |                 | 100  |               |
| $I_{SC}$   | Bus Output Short Circuit Current        | $V_{CC} = \text{MAX}, V_O = 0\text{V}$     | -50                            |                 | -255 | mA            |
| $C_B$      | Bus Capacitance (Note 4)                | $V_{CC} = 0\text{V}$                       |                                | 8               |      | pF            |

- Notes: 1. For conditions shown as MIN. or MAX., use the appropriate value specified under Electrical Characteristics for the applicable device type.  
2. Typical limits are at  $V_{CC} = 5.0\text{V}$ ,  $25^\circ\text{C}$  ambient and maximum loading.  
3. Not more than one output should be shorted at a time. Duration of the short circuit test should not exceed one second.  
4. This parameter is typical of device characterization data and is not tested in production.

## ELECTRICAL CHARACTERISTICS

The Following Conditions Apply Unless Otherwise Specified:

|       |  |                                 |                             |
|-------|--|---------------------------------|-----------------------------|
| COM'L | $T_A = 0^\circ\text{C to } +70^\circ\text{C}$    | $V_{CC} = 5.0\text{V} \pm 5\%$  | (MIN. = 4.75V MAX. = 5.25V) |
| MIL   | $T_A = -55^\circ\text{C to } +125^\circ\text{C}$ | $V_{CC} = 5.0\text{V} \pm 10\%$ | (MIN. = 4.50V MAX. = 5.50V) |

## DC CHARACTERISTICS OVER OPERATING RANGE

| Parameters | Description                                   | Test Conditions (Note 1)                                | Min                             | Typ<br>(Note 2) | Max  | Units         |
|------------|---|---|---------------------------------|-----------------|------|---------------|
| $V_{OH}$   | Receiver Output HIGH Voltage                  | $V_{CC} = \text{MIN.}$<br>$V_{IN} = V_{IH}$ or $V_{IL}$ | MIL, $I_{OH} = -2.0\text{mA}$   | 2.4             | 3.4  | Volts         |
|            |   |   | COM'L, $I_{OH} = -6.5\text{mA}$ | 2.4             | 3.4  |               |
|            |   | $V_{CC} = 5.0\text{V}$                                  | $I_{OH} = -100\mu\text{A}$      | 3.5             |      |               |
| $V_{OL}$   | Output LOW Voltage (Except Bus)               | $V_{CC} = \text{MIN}$<br>$V_{IN} = V_{IL}$ or $V_{IH}$  | $I_{OL} = 20\text{mA}$          |                 | 0.5  | Volts         |
| $V_{IH}$   | Input HIGH Level (Except Bus)                 | Guaranteed input logical<br>HIGH voltage for all inputs |                                 | 2.0             |      | Volts         |
| $V_{IL}$   | Input LOW Level                               | Guaranteed input logical<br>LOW voltage for all inputs  | MIL                             |                 | 0.8  | Volts         |
|            |   |   | COM'L                           |                 | 0.8  |               |
| $V_I$      | Input Clamp Voltage                           | $V_{CC} = \text{MIN.}, I_{IN} = -18\text{mA}$           |                                 |                 | -1.2 | Volts         |
| $I_{IL}$   | Input LOW Current (Except Bus)                | $V_{CC} = \text{MAX.}, V_{IN} = 0.5\text{V}$            |                                 |                 | -2.0 | mA            |
| $I_{IH}$   | Input HIGH Current (Except Bus)               | $V_{CC} = \text{MAX.}, V_{IN} = 2.7\text{V}$            | S, ENDR                         |                 | 100  | $\mu\text{A}$ |
|            |   |   | All other inputs                |                 | 50   |               |
| $I_I$      | Input HIGH Current (Except Bus)               | $V_{CC} = \text{MAX.}, V_{IN} = 7.0\text{V}$            | S, ENDR                         |                 | 2.0  | mA            |
|            |   |   | All other inputs                |                 | 1.0  |               |
| $I_O$      | Off-State Output Current<br>(Receiver Output) | $V_{CC} = \text{MAX.}$                                  | $V_O = 2.4\text{V}$             |                 | 50   | $\mu\text{A}$ |
|            |   |   | $V_O = 0.5\text{V}$             |                 | -50  |               |
| $I_{SC}$   | Output Short Circuit Current<br>(Except Bus)  | $V_{CC} = \text{MAX.}$                                  | Receiver                        | -40             | -100 | mA            |
| $I_{CC}$   | Power Supply Current                          | $V_{CC} = \text{MAX.}$                                  |                                 |                 |      | mA            |



## Am2927

## SWITCHING CHARACTERISTICS OVER OPERATING TEMPERATURE RANGE

| Parameters        | Description  | Test Conditions                                  | Am2927XM |     |     | Am2927XC |     |     | Units |
|-------------------|--|--|----------|-----|-----|----------|-----|-----|-------|
|                   |  |  | Min      | Typ | Max | Min      | Typ | Max |       |
| $t_{PLH}$         | Driver Clock, CP, to $\overline{BUS}$                  | $C_L$ (BUS) = 50pF<br>$R_L$ (BUS) = 130 $\Omega$ |          |     |     |          | 18  |     | ns    |
| $t_{PHL}$         |  |  |          |     |     |          | 18  |     |       |
| $t_{ZH} * t_{ZL}$ | Bus Enable, $\overline{BE}$ , to $\overline{BUS}$      | $C_L = 5pF$                                      |          |     |     |          | 14  |     | ns    |
| $t_{HZ} * t_{LZ}$ |  |  |          |     |     |          | 12  |     |       |
| $t_{PW}$          | Min. Clock Pulse Width (HIGH or LOW)                   |  |          |     |     | 10       |     |     | ns    |
| $t_{PLH}$         | $\overline{BUS}$ to Receiver Output (Latch Enabled)    |  |          |     |     |          | 16  |     | ns    |
| $t_{PHL}$         |  |  |          |     |     |          | 16  |     |       |
| $t_{PLH}$         | Latch Enable, $\overline{RLE}$ , to Receiver Output    |  |          |     |     |          | 18  |     | ns    |
| $t_{PHL}$         |  |  |          |     |     |          | 18  |     |       |
| $t_{ZH} * t_{ZL}$ | Output Enable, $\overline{OE}$ , to Output             | $C_L = 15pF, R_L = 2.0k\Omega$                   |          |     |     |          | 16  |     | ns    |
| $t_{HZ} * t_{LZ}$ |  | $C_L = 5pF, R_L = 2.0k\Omega$                    |          |     |     |          | 14  |     |       |
| $t_s$             | Driver Enable, $\overline{ENDR}$ , to Clock            |  |          |     |     | 8        |     |     | ns    |
| $t_h$             |  |  |          |     |     | 2        |     |     |       |
| $t_s$             | Select, S, to Clock ( $\overline{RLE} = \text{HIGH}$ ) |  |          |     |     | 10       |     |     | ns    |
| $t_h$             |  |  |          |     |     | 0        |     |     |       |
| $t_s$             | Select, S, to Clock ( $\overline{RLE} = \text{LOW}$ )  |  |          |     |     | 13       |     |     | ns    |
| $t_h$             |  |  |          |     |     | 0        |     |     |       |
| $t_s$             | Data Inputs, D, to Clock                               |  |          |     |     | 7        |     |     | ns    |
| $t_h$             |  |  |          |     |     | 2        |     |     |       |
| $t_s$             | $\overline{BUS}$ to Latch Enable, $\overline{RLE}$     |  |          |     |     | 10       |     |     | ns    |
| $t_h$             |  |  |          |     |     | 3        |     |     |       |

Notes: 1. For conditions shown as MIN. or MAX., use the appropriate value specified under Electrical Characteristics for the applicable device type.

2. Typical limits are at  $V_{CC} = 5.0V$ , 25°C ambient and maximum loading.

3. Not more than one output should be shorted at a time. Duration of the short circuit test should not exceed one second.

## Am2928

## SWITCHING CHARACTERISTICS OVER OPERATING TEMPERATURE RANGE

| Parameters        | Description                                       | Test Conditions                                  | Am2928XM |     |     | Am2928XC |     |     | Units |
|-------------------|---|--|----------|-----|-----|----------|-----|-----|-------|
|                   |   |  | Min      | Typ | Max | Min      | Typ | Max |       |
| $t_{PLH}$         | Clock, CP, to $\overline{BUS}$                    | $C_L$ (BUS) = 50pF<br>$R_L$ (BUS) = 130 $\Omega$ |          |     |     |          | 18  |     | ns    |
| $t_{PHL}$         |   |  |          |     |     |          | 18  |     |       |
| $t_{ZH} * t_{ZL}$ | Bus Enable, $\overline{BE}$ , to $\overline{BUS}$ | $C_L = 5pF$                                      |          |     |     |          | 14  |     | ns    |
| $t_{HZ} * t_{LZ}$ |   |  |          |     |     |          | 12  |     |       |
| $t_{PLH}$         | Clock, CP, to Output, Y                           | $C_L = 15pF, R_L = 2.0k\Omega$                   |          |     |     |          | 18  |     | ns    |
| $t_{PHL}$         |   |  |          |     |     |          | 18  |     |       |
| $t_{PW}$          | Min. Clock Pulse Width (HIGH or LOW)              |  |          |     |     | 10       |     |     | ns    |
| $t_{ZH} * t_{ZL}$ | Output Enable, $\overline{OE}$ , to Output, Y     | $C_L = 15pF, R_L = 2.0k\Omega$                   |          |     |     |          | 16  |     | ns    |
| $t_{HZ} * t_{LZ}$ |   | $C_L = 5pF, R_L = 2.0k\Omega$                    |          |     |     |          | 14  |     |       |
| $t_s$             | Driver Enable, $\overline{ENDR}$ , to Clock       |  |          |     |     | 8        |     |     | ns    |
| $t_h$             |   |  |          |     |     | 2        |     |     |       |
| $t_s$             | $\overline{BUS}$ to Clock (Receiver Register)     |  |          |     |     | 7        |     |     | ns    |
| $t_h$             |   |  |          |     |     | 2        |     |     |       |
| $t_s$             | Receiver Enable, $\overline{ENREC}$ , to Clock    |  |          |     |     | 8        |     |     | ns    |
| $t_h$             |   |  |          |     |     | 2        |     |     |       |
| $t_s$             | S to Clock  |  |          |     |     | 10       |     |     | ns    |
| $t_h$             |   |  |          |     |     | 0        |     |     |       |
| $t_s$             | Data Inputs, D, to Clock (Driver Register)        |  |          |     |     | 7        |     |     | ns    |
| $t_h$             |   |  |          |     |     | 2        |     |     |       |

Notes: 1. For conditions shown as MIN. or MAX., use the appropriate value specified under Electrical Characteristics for the applicable device type.

2. Typical limits are at  $V_{CC} = 5.0V$ , 25°C ambient and maximum loading.

3. Not more than one output should be shorted at a time. Duration of the short circuit test should not exceed one second.



|  |  |                                      |  |
|--|--|--------------------------------------|--|
| <b>CP</b>  | Clock Pulse to internal registers enters data on the LOW-to-HIGH transition.   | <b>OE</b>                            | Output Enable. When Output Enable is LOW the four receiver outputs Y are active.   |
| <b><math>\overline{BE}</math></b>  | Bus Enable. When Bus Enable is LOW the four drivers drive the $\overline{BUS}$ outputs.                                    | <b><math>\overline{ENDR}</math></b>  | Driver Enable. Common clock enable for the input register. Allows the data on the D inputs to be loaded into the driver register on the clock LOW-to-HIGH transition.                                      |
| <b><math>\overline{BUS}_0, \overline{BUS}_1, \overline{BUS}_2, \overline{BUS}_3</math></b> | The four driver outputs and receiver inputs.   | <b><math>\overline{RLE}</math></b>   | Receiver Latch Enable (Am2927 only). When Receiver Latch Enable is LOW, the four receiver latches are transparent. The latches hold received data when $\overline{RLE}$ is HIGH.                           |
| <b><math>D_0, D_1, D_2, D_3</math></b>   | The four driver data inputs inverting from D to $\overline{BUS}$ .   | <b><math>\overline{ENREC}</math></b> | Receiver Enable (Am2928 only). Common clock enable for the receiver register. Allows the $\overline{BUS}$ driver or previous receiver data to enter the receiver register on the rising edge of the clock. |
| <b><math>Y_0, Y_1, Y_2, Y_3</math></b>   | The four receiver data outputs inverting from $\overline{BUS}$ to Y.   |                                      |  |
| <b>S</b>   | Select input controls data path modes in conjunction with $\overline{ENDR}$ and $\overline{RLE}$ (or $\overline{ENREC}$ ). |                                      |  |

#### Am2927 FUNCTION TABLES

Driver Register Control

| $\overline{ENDR}$ | S | $\overline{RLE}$ | Driver Register            |
|-------------------|---|------------------|----------------------------|
| H                 | X | X                | Hold Previous Data         |
| L                 | L | X                | Load from D Input          |
| L                 | H | L                | Load from $\overline{BUS}$ |
| L                 | H | H                | Load Latched Receiver Data |

Receiver Latch Control

| $\overline{ENDR}$ | S | $\overline{RLE}$ | Receiver Output  |
|-------------------|---|------------------|--|
| X                 | X | H                | Data Latched   |
| H                 | H | L                | Driver Register Output at Y Output (Latch Transparent) |
| X                 | L | L                | Bus Data at Y Output (Latch Transparent)               |
| L                 | X | L                |  |

#### Am2928 FUNCTION TABLES

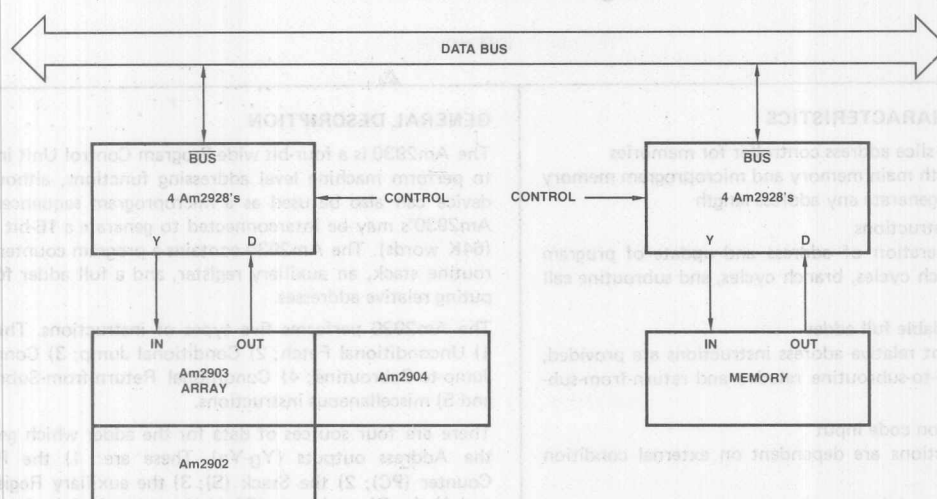
Driver Register Control

| $\overline{ENDR}$ | S | Driver Register             |
|-------------------|---|-----------------------------|
| H                 | X | Hold Previous Data          |
| L                 | L | Load from D Input           |
| L                 | H | Load from Receiver Register |

Receiver Register Control

| $\overline{ENDR}$ | S | $\overline{ENREC}$ | Receiver Output            |
|-------------------|---|--------------------|----------------------------|
| X                 | X | H                  | Hold Previous Data         |
| H                 | H | L                  | Load from Driver Register  |
| X                 | L | L                  | Load from $\overline{BUS}$ |
| L                 | X | L                  |                            |

## APPLICATION



2

The Am2927 and Am2928 can be used to provide Data Bus, Address Bus and Control Bus Interface in a high-speed bipolar microprocessor system.

BLI-093

Am2927 AND Am2928 FUNCTION TABLE

| Driver Input From | Receiver Input From | Control Input Condition |                   |   | Signal Flow | $\overline{BE}$ |
|-------------------|---------------------|-------------------------|-------------------|---|-------------|-----------------|
|                   |                     | S                       | $\overline{ENDR}$ | * |             |                 |
| D Input           | BUS                 | L                       | L                 | L |             | H               |
|                   | (No Load)           | L                       | L                 | H |             | L               |
| Receiver          | BUS                 | H                       | L                 | L |             | H               |
|                   | (No Load)           | H                       | L                 | H |             | L               |
| (No Load)         | BUS                 | L                       | H                 | L |             | H               |
|                   | Driver              | H                       | H                 | L |             | X               |
|                   | (No Load)           | X                       | H                 | H |             | L               |

\*RLE for Am2927 (asynchronous) or ENREC for Am2928 (5).

# Am2930

## Program Control Unit

### DISTINCTIVE CHARACTERISTICS

- Powerful, 4-bit slice address controller for memories  
Useful with both main memory and microprogram memory  
Expandable to generate any address length
- Executes 32 instructions  
Automatic generation of address and update of program counter for fetch cycles, branch cycles, and subroutine call and return
- Contains cascadable full adder  
Twelve different relative address instructions are provided, including jump-to-subroutine relative and return-from-subroutine relative
- Built-in condition code input  
Sixteen instructions are dependent on external condition control
- Seventeen-level push/pop stack  
On-chip storage of subroutine return addresses nested up to 17 levels deep
- Separate incrementer for program counter  
A relative address may be computed and PC may be incremented by one on a single cycle

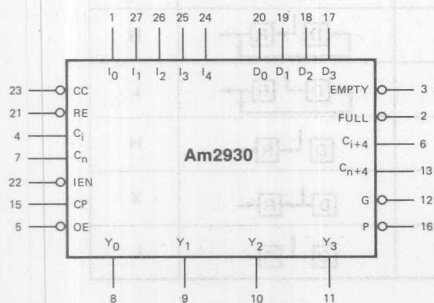
### GENERAL DESCRIPTION

The Am2930 is a four-bit wide Program Control Unit intended to perform machine level addressing functions, although the device can also be used as a microprogram sequencer. Four Am2930's may be interconnected to generate a 16-bit address (64K words). The Am2930 contains a program counter, a subroutine stack, an auxiliary register, and a full adder for computing relative addresses.

The Am2930 performs five types of instructions. These are: 1) Unconditional Fetch; 2) Conditional Jump; 3) Conditional Jump-to-Subroutine; 4) Conditional Return-from-Subroutine; and 5) miscellaneous instructions.

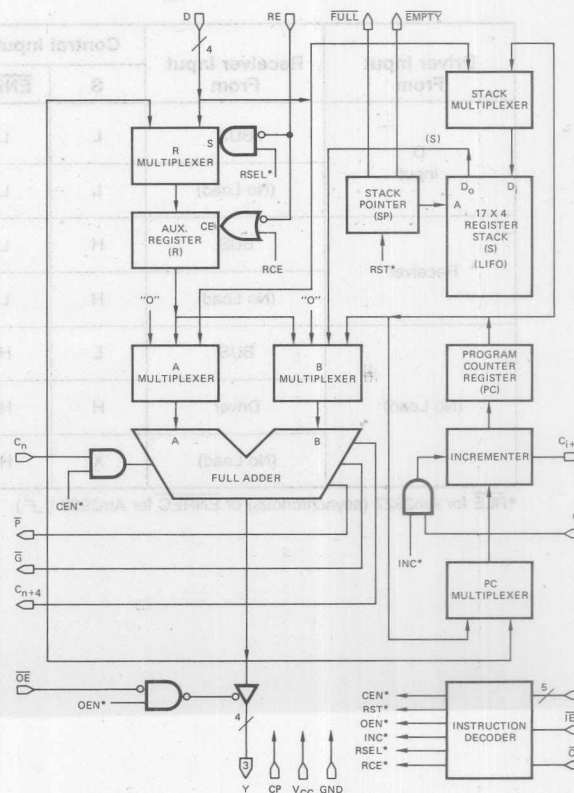
There are four sources of data for the adder which generates the Address outputs ( $Y_0$ - $Y_3$ ). These are: 1) the Program Counter (PC); 2) the Stack (S); 3) the auxiliary Register (R); and 4) the Direct inputs (D). Under control of the Instruction inputs ( $I_0$ - $I_4$ ), the multiplexers at the adder inputs allow various combinations of these terms to be generated at the three-state Y address outputs. The instruction lines also control the updating of the program counter and the auxiliary register. A condition code input is provided for conditional instructions.

### LOGIC SYMBOL



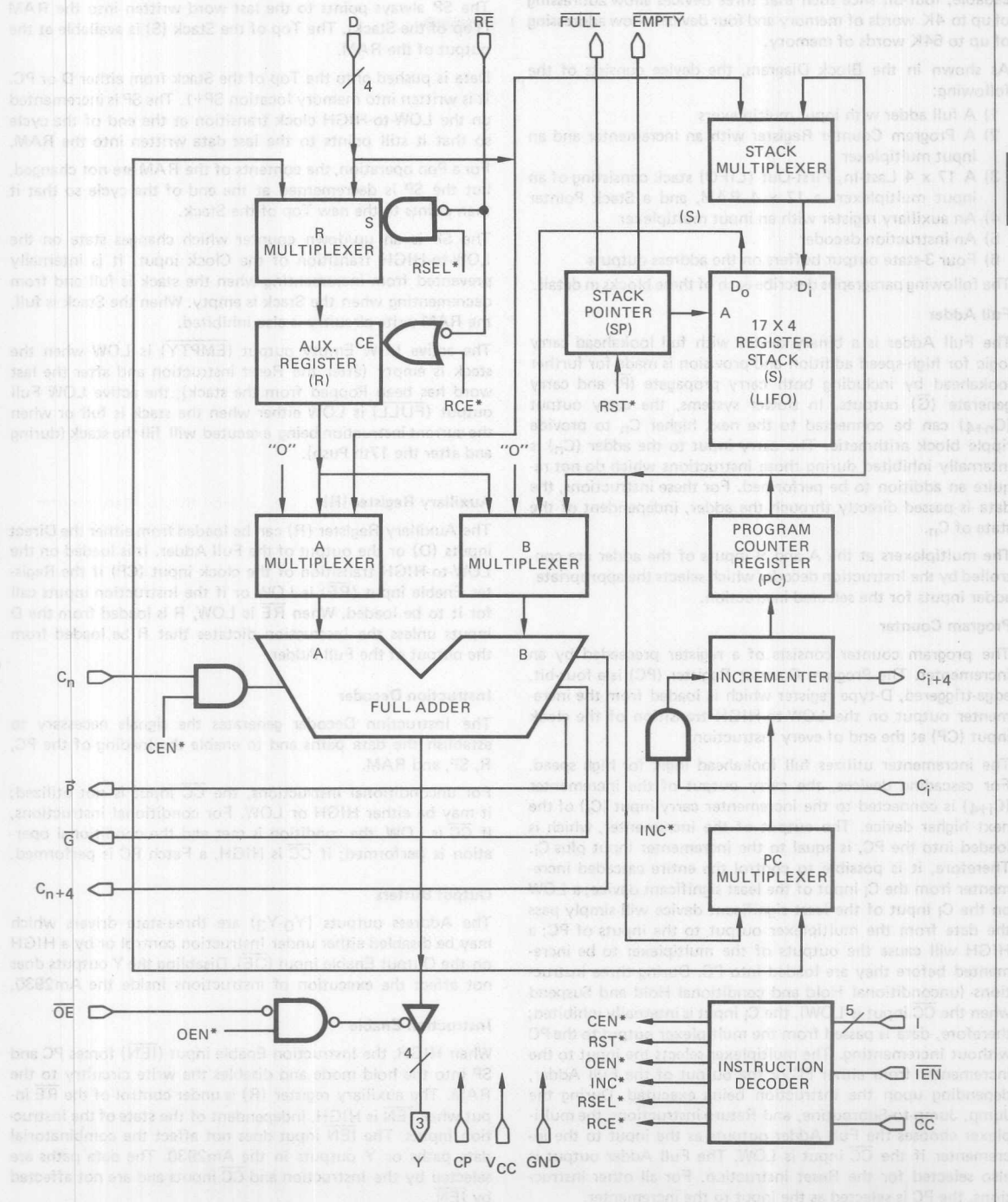
$V_{CC}$  = Pin 28  
GND = Pin 14

### BLOCK DIAGRAM



MPR-220

MPR-221



## ARCHITECTURE OF THE Am2930

The Am2930 is a bipolar Program Control Unit intended for use in high-speed microprocessor applications. The device is a cascable, four-bit slice such that three devices allow addressing of up to 4K words of memory and four devices allow addressing of up to 64K words of memory.

As shown in the Block Diagram, the device consists of the following:

- 1) A full adder with input multiplexers
- 2) A Program Counter Register with an incrementer and an input multiplexer
- 3) A 17 x 4 Last-In, First-Out (LIFO) stack consisting of an input multiplexer, a 17 x 4 RAM, and a Stack Pointer
- 4) An auxiliary register with an input multiplexer
- 5) An instruction decoder
- 6) Four 3-state output buffers on the address outputs

The following paragraphs describe each of these blocks in detail.

### Full Adder

The Full Adder is a binary device with full lookahead carry logic for high-speed addition and provision is made for further lookahead by including both carry propagate ( $\bar{P}$ ) and carry generate ( $\bar{G}$ ) outputs. In slower systems, the carry output ( $C_{n+4}$ ) can be connected to the next higher  $C_n$  to provide ripple block arithmetic. The carry input to the adder ( $C_n$ ) is internally inhibited during those instructions which do not require an addition to be performed. For these instructions, the data is passed directly through the adder, independent of the state of  $C_n$ .

The multiplexers at the A and B inputs of the adder are controlled by the Instruction decoder which selects the appropriate adder inputs for the selected instruction.

### Program Counter

The program counter consists of a register preceded by an incrementer. The Program Counter Register (PC) is a four-bit, edge-triggered, D-type register which is loaded from the incrementer output on the LOW-to-HIGH transition of the clock input (CP) at the end of every instruction.

The incrementer utilizes full lookahead logic for high speed. For cascading devices, the carry output of the incrementer ( $C_{i+4}$ ) is connected to the incrementer carry input ( $C_i$ ) of the next higher device. The output of the incrementer, which is loaded into the PC, is equal to the incrementer input plus  $C_i$ . Therefore, it is possible to control the entire cascaded incrementer from the  $C_i$  input of the least significant device; a LOW on the  $C_i$  input of the least significant device will simply pass the data from the multiplexer output to the inputs of PC; a HIGH will cause the outputs of the multiplexer to be incremented before they are loaded into PC. During three instructions (unconditional Hold and conditional Hold and Suspend when the  $\bar{CC}$  input is LOW), the  $C_i$  input is internally inhibited; therefore, data is passed from the multiplexer output to the PC without incrementing. The multiplexer selects the input to the incrementer from either PC or the output of the Full Adder, depending upon the instruction being executed. During the Jump, Jump-to-Subroutine, and Return instructions, the multiplexer chooses the Full Adder outputs as the input to the incrementer if the  $\bar{CC}$  input is LOW. The Full Adder output is also selected for the Reset instruction. For all other instructions, the PC is selected as the input to the incrementer.

### 17 x 4 LIFO Stack

The 17 x 4 LIFO stack consists of a multiplexer, a 17 x 4 RAM, and a Stack Pointer (SP) which address the words in the RAM.

The SP always points to the last word written into the RAM (Top of the Stack). The Top of the Stack (S) is available at the output of the RAM.

Data is pushed onto the Top of the Stack from either D or PC. It is written into memory location SP+1. The SP is incremented on the LOW-to-HIGH clock transition at the end of the cycle so that it still points to the last data written into the RAM.

For a Pop operation, the contents of the RAM are not changed, but the SP is decremented at the end of the cycle so that it then points to the new Top of the Stack.

The SP is an up/down counter which changes state on the LOW-to-HIGH transition of the Clock input. It is internally prevented from incrementing when the stack is full and from decrementing when the Stack is empty. When the Stack is full, the RAM write circuitry is also inhibited.

The active LOW Empty output ( $\overline{EMPTY}$ ) is LOW when the stack is empty (after the Reset instruction, and after the last word has been Popped from the stack); the active LOW Full output ( $\overline{FULL}$ ) is LOW either when the stack is full or when the current instruction being executed will fill the stack (during and after the 17th Push).

### Auxiliary Register (R)

The Auxiliary Register (R) can be loaded from either the Direct inputs (D) or the output of the Full Adder. It is loaded on the LOW-to-HIGH transition of the clock input (CP) if the Register Enable input ( $\overline{RE}$ ) is LOW or if the Instruction inputs call for it to be loaded. When  $\overline{RE}$  is LOW, R is loaded from the D inputs unless the Instruction dictates that R be loaded from the output of the Full Adder.

### Instruction Decoder

The Instruction Decoder generates the signals necessary to establish the data paths and to enable the loading of the PC, R, SP, and RAM.

For unconditional instructions, the  $\bar{CC}$  input is not utilized; it may be either HIGH or LOW. For conditional instructions, if  $\bar{CC}$  is LOW, the condition is met and the conditional operation is performed; if  $\bar{CC}$  is HIGH, a Fetch PC is performed.

### Output Buffers

The Address outputs ( $Y_0$ - $Y_3$ ) are three-state drivers which may be disabled either under Instruction control or by a HIGH on the Output Enable input ( $\overline{OE}$ ). Disabling the Y outputs does not affect the execution of instructions inside the Am2930.

### Instruction Enable

When HIGH, the Instruction Enable input ( $\overline{IEN}$ ) forces PC and SP into the hold mode and disables the write circuitry to the RAM. The auxiliary register (R) is under control of the  $\overline{RE}$  input when  $\overline{IEN}$  is HIGH, independent of the state of the Instruction inputs. The  $\overline{IEN}$  input does not affect the combinatorial data paths or Y outputs in the Am2930. The data paths are selected by the Instruction and  $\bar{CC}$  inputs and are not affected by  $\overline{IEN}$ .



## Am2930 INSTRUCTION SET

The Am2930 Instruction set can be divided into five types of instructions. These are:

- Unconditional Fetches
- Conditional Jumps
- Conditional Jumps-to-Subroutine
- Conditional Returns-from-Subroutine
- Miscellaneous Instructions

The following paragraphs describe each of these types in detail.

### Unconditional Fetches

As can be seen from Table 1, there are nine unconditional Fetch instructions (Instructions 1-9). Under control of the Instruction inputs, the desired function is placed at the Y outputs. For all Fetch instructions, PC is incremented if  $C_i$  of the least significant device is HIGH. For Instructions 1 through 7, the auxiliary register is under control of the RE input. For Instructions 8 and 9, R is loaded with PC and R + D, respectively. The RAM and Stack Pointer are not changed during a Fetch instruction.

### Conditional Jumps

There are six conditional Jump instructions (Instructions 16 through 21). Under control of the Instruction inputs, the desired function is placed at the Y outputs. Additionally, the desired function is incremented if  $C_i$  of the least significant device is HIGH and loaded into PC. During these instructions, R is controlled by  $\overline{RE}$ . The RAM and Stack Pointer are not changed during these instructions. The above operations are performed if the  $\overline{CC}$  input is LOW; if  $\overline{CC}$  is HIGH, a Fetch PC operation is performed.

### Conditional Jumps-to-Subroutine

There are six conditional Jump-to-Subroutine instructions (Instructions 22 through 27). Under control of the Instruction inputs, the desired function is placed on the Y outputs. On the rising edge of the clock the data on the Y outputs is incremented and loaded into PC, PC is loaded into the RAM at location SP+1; and SP is incremented.

As with Conditional Jump Instructions, R is controlled by  $\overline{RE}$  and whether the Jump-to-Subroutine or Fetch PC is performed depends upon the state of the  $\overline{CC}$  input.

### Conditional Returns-from-Subroutine

There are two conditional Return-from-Subroutine instructions (Instructions 28 and 29). Under control of the instruction inputs, either S or S+D is placed at the Y outputs. Additionally, the selected function is incremented and loaded into PC and SP is decremented at the end of the cycle (on the rising edge of the clock).

As with the Condition Jump and Jump-to-Subroutine Instructions, R is controlled by  $\overline{RE}$  and whether the Return-from-Subroutine or Fetch PC is performed depends upon the state of the  $\overline{CC}$  input.

### Miscellaneous Instructions

Each of the nine miscellaneous instructions is described individually.

#### Reset (Instruction 0)

The Reset instruction forces the Y outputs to zero, loads either zero or one into PC, depending upon the  $C_i$  input of the least significant device, and resets SP. The RAM is unchanged and R is controlled by  $\overline{RE}$ .

#### Load R (Instruction 10)

This instruction loads the data on the D inputs into R. PC is either incremented or held depending upon  $C_i$  of the least significant device. The SP and RAM are not changed.

#### Push PC (Instruction 11)

This instruction is the same as Fetch PC except that PC is loaded into RAM and SP is incremented at the end of the cycle; i.e., the current PC is Pushed onto the stack.

#### Push D (Instruction 12)

This instruction is the same as Fetch PC except that D is loaded into the RAM and SP is incremented at the end of the cycle; i.e., external data is Pushed onto the stack.

#### Pop S (Instruction 13)

This instruction places the Top of the Stack (S) at the Y outputs and decrements SP at the end of the cycle. The PC is incremented if the  $C_i$  input of the least significant device is HIGH. R is controlled by  $\overline{RE}$ .

#### Pop PC (Instruction 14)

This instruction is the same as Fetch PC except SP is decremented at the end of the cycle, causing the data at the top of the stack to be lost.

#### Hold (Instruction 15)

This instruction places PC at the Y outputs and inhibits any change in PC, SP, and RAM. R is controlled by  $\overline{RE}$ .

#### Conditional Hold (Instruction 30)

This instruction is the same as Hold except  $\overline{CC}$  must be LOW. If  $\overline{CC}$  is HIGH, the Fetch PC instruction is performed.

#### Suspend (Instruction 31)

The Suspend instruction is the same as the Conditional Hold instruction except the Y outputs are forced into the high-impedance state if  $\overline{CC}$  is LOW.

TABLE I — Am2930 INSTRUCTION SET

| Mnemonic | Instruction Number | I <sub>4</sub> I <sub>3</sub> I <sub>2</sub> I <sub>1</sub> I <sub>0</sub> CC IEN | Instruction                 | Y <sub>0</sub> -Y <sub>3</sub> | Next State (after CP $\downarrow$ ) (Note 3) |                    |                    |               |       |
|----------|--------------------|---|-----------------------------|--------------------------------|--|--------------------|--------------------|---------------|-------|
|          |                    |   |                             |                                | PC   | R                  |                    | RAM           | SP    |
|          |                    |   |                             |                                |  | RE = L             | RE = H             |               |       |
|          |                    | X X X X X X H   | Instruction Disable         | Note 1                         | —  | D                  | —                  | —             | —     |
| PRST     | 0                  | L L L L L X L   | RESET                       | "0"                            | "0"+C <sub>i</sub>                           | D                  | —                  | —             | Reset |
| FPC      | 1                  | L L L L H X L   | FETCH PC                    | PC                             | PC+C <sub>i</sub>                            | D                  | —                  | —             | —     |
| FR       | 2                  | L L L H L X L   | FETCH R                     | R                              | PC+C <sub>i</sub>                            | D                  | —                  | —             | —     |
| FD       | 3                  | L L L H H X L   | FETCH D                     | D                              | PC+C <sub>i</sub>                            | D                  | —                  | —             | —     |
| FRD      | 4                  | L L H L L X L   | FETCH R+D                   | R+D+C <sub>n</sub>             | PC+C <sub>i</sub>                            | D                  | —                  | —             | —     |
| FPD      | 5                  | L L H L H X L   | FETCH PC+D                  | PC+D+C <sub>n</sub>            | PC+C <sub>i</sub>                            | D                  | —                  | —             | —     |
| FPR      | 6                  | L L H H L X L   | FETCH PC+R                  | PC+R+C <sub>n</sub>            | PC+C <sub>i</sub>                            | D                  | —                  | —             | —     |
| FSD      | 7                  | L L H H H X L   | FETCH S+D                   | S+D+C <sub>n</sub>             | PC+C <sub>i</sub>                            | D                  | —                  | —             | —     |
| FPLR     | 8                  | L H L L L X L   | FETCH PC → R                | PC                             | PC+C <sub>i</sub>                            | PC                 | PC                 | —             | —     |
| FRDR     | 9                  | L H L L H X L   | FETCH R+D → R               | R+D+C <sub>n</sub>             | PC+C <sub>i</sub>                            | R+D+C <sub>n</sub> | R+D+C <sub>n</sub> | —             | —     |
| PLDR     | 10                 | L H L H L X L   | LOAD R                      | PC                             | PC+C <sub>i</sub>                            | D                  | D                  | —             | —     |
| PSHP     | 11                 | L H L H H X L   | PUSH PC                     | PC                             | PC+C <sub>i</sub>                            | D                  | —                  | PC → Loc SP+1 | SP+1  |
| PSHD     | 12                 | L H H L L X L   | PUSH D                      | PC                             | PC+C <sub>i</sub>                            | D                  | —                  | D → Loc SP+1  | SP+1  |
| POPS     | 13                 | L H H L H X L   | POP S                       | S                              | PC+C <sub>i</sub>                            | D                  | —                  | —             | SP-1  |
| POPP     | 14                 | L H H H L X L   | POP PC                      | PC                             | PC+C <sub>i</sub>                            | D                  | —                  | —             | SP-1  |
| PHLD     | 15                 | L H H H H X L   | HOLD                        | PC                             | —  | D                  | —                  | —             | —     |
|          | 16-31              | H X X X X H L   | FAIL COND'L TEST (FETCH PC) | PC                             | PC+C <sub>i</sub>                            | D                  | —                  | —             | —     |
| JMPR     | 16                 | H L L L L L L   | JUMP R                      | R                              | R+C <sub>i</sub>                             | D                  | —                  | —             | —     |
| JMPD     | 17                 | H L L L H L L   | JUMP D                      | D                              | D+C <sub>i</sub>                             | D                  | —                  | —             | —     |
| JMPZ     | 18                 | H L L L L L L   | JUMP "0"                    | "0"                            | "0"+C <sub>i</sub>                           | D                  | —                  | —             | —     |
| JPRD     | 19                 | H L L H H L L   | JUMP R+D                    | R+D+C <sub>n</sub>             | R+D+C <sub>n</sub> +C <sub>i</sub>           | D                  | —                  | —             | —     |
| JPPD     | 20                 | H L H L L L L   | JUMP PC+D                   | PC+D+C <sub>n</sub>            | PC+D+C <sub>n</sub> +C <sub>i</sub>          | D                  | —                  | —             | —     |
| JPPR     | 21                 | H L H L H L L   | JUMP PC+R                   | PC+R+C <sub>n</sub>            | PC+R+C <sub>n</sub> +C <sub>i</sub>          | D                  | —                  | —             | —     |
| JSBR     | 22                 | H L H H L L L   | JSB R                       | R                              | R+C <sub>i</sub>                             | D                  | —                  | PC → Loc SP+1 | SP+1  |
| JSBD     | 23                 | H L H H H L L   | JSB D                       | D                              | D+C <sub>i</sub>                             | D                  | —                  | PC → Loc SP+1 | SP+1  |
| JSBZ     | 24                 | H H L L L L L   | JSB "0"                     | "0"                            | "0"+C <sub>i</sub>                           | D                  | —                  | PC → Loc SP+1 | SP+1  |
| JSRD     | 25                 | H H L L H L L   | JSB R+D                     | R+D+C <sub>n</sub>             | R+D+C <sub>n</sub> +C <sub>i</sub>           | D                  | —                  | PC → Loc SP+1 | SP+1  |
| JSPD     | 26                 | H H L H L L L   | JSB PC+D                    | PC+D+C <sub>n</sub>            | PC+D+C <sub>n</sub> +C <sub>i</sub>          | D                  | —                  | PC → Loc SP+1 | SP+1  |
| JSPR     | 27                 | H H L H H L L   | JSB PC+R                    | PC+R+C <sub>n</sub>            | PC+R+C <sub>n</sub> +C <sub>i</sub>          | D                  | —                  | PC → Loc SP+1 | SP+1  |
| RTS      | 28                 | H H H L L L L   | RETURN S                    | S                              | S+C <sub>i</sub>                             | D                  | —                  | —             | SP-1  |
| RTSD     | 29                 | H H H L H L L   | RETURN S+D                  | S+D+C <sub>n</sub>             | S+D+C <sub>n</sub> +C <sub>i</sub>           | D                  | —                  | —             | SP-1  |
| CHLD     | 30                 | H H H H L L L   | HOLD                        | PC                             | —  | D                  | —                  | —             | —     |
| PSUS     | 31                 | H H H H H L L   | SUSPEND                     | Z (Note 2)                     | —  | D                  | —                  | —             | —     |

PC — Program Counter  
R — Auxiliary Register

SP — Stack Pointer  
D — Direct Inputs

Notes: 1. When IEN is HIGH, the Y<sub>0</sub>-Y<sub>3</sub> outputs contain the same data as when IEN is LOW, as determined by I<sub>0</sub>-I<sub>4</sub> and CC.

2. Z = High impedance state (outputs "OFF").  
3. — = No change

**MAXIMUM RATINGS** (Above which the useful life may be impaired)

|   |                        |
|---|------------------------|
| Storage Temperature                                 | -65 to +150°C          |
| Temperature (Ambient) Under Bias                    | -55 to +125°C          |
| Supply Voltage to Ground Potential                  | -0.5 to +7.0V          |
| DC Voltage Applied to Outputs for High Output State | -0.5V to $V_{CC}$ max. |
| DC Input Voltage                                    | -0.5 to +5.5V          |
| DC Output Current, Into Outputs                     | 30mA                   |
| DC Input Current                                    | -30 to +5.0mA          |

**OPERATING RANGE**

| Part Number  | Temperature                         | $V_{CC}$       |
|--------------|-------------------------------------|----------------|
| Am2930PC, DC | $T_A = 0$ to $70^\circ\text{C}$     | 4.75V to 5.25V |
| Am2930DM, FM | $T_C = -55$ to $+125^\circ\text{C}$ | 4.50V to 5.50V |

**DC CHARACTERISTICS OVER OPERATING RANGE**

| Parameters | Description                              | Test Conditions (Note 1)   | Min   | Typ<br>(Note 2) | Max    | Units         |
|------------|--|--|---|-----------------|--------|---------------|
| $V_{OH}$   | Output HIGH Voltage                      | $V_{CC} = \text{MIN.},$<br>$V_{IN} = V_{IL} \text{ or } V_{IH}$<br>$Y_0, Y_1, Y_2, Y_3$<br>$\bar{G}, C_{n+4},$<br>$C_{i+4}$<br>$\bar{P}, \text{FULL},$<br>$\text{EMPTY}$ | $I_{OH} = -1.6\text{mA}$  | 2.4             |        | Volts         |
|            |  |  | $I_{OH} = -1.2\text{mA}$  | 2.4             |        |               |
| $V_{OL}$   | Output LOW Voltage                       | $V_{CC} = \text{MIN.},$<br>$V_{IN} = V_{IL} \text{ or } V_{IH}$<br>$Y_0, Y_1, Y_2, Y_3$<br>$\bar{G}, C_{n+4},$<br>$C_{i+4}$<br>$\bar{P}, \text{FULL},$<br>$\text{EMPTY}$ | $I_{OL} = 20\text{mA}$<br>(COM'L)   |                 | 0.5    | Volts         |
|            |  |  | $I_{OL} = 16\text{mA (MIL)}$  |                 | 0.5    |               |
|            |  |  | $I_{OL} = 16\text{mA}$  |                 | 0.5    |               |
|            |  |  | $I_{OL} = 12\text{mA}$  |                 | 0.5    |               |
| $V_{IH}$   | Input HIGH Level (Note 4)                |  | 2.0   |                 |        | Volts         |
| $V_{IL}$   | Input LOW Level (Note 4)                 |  |   |                 | 0.8    | Volts         |
| $V_I$      | Input Clamp Voltage                      | $V_{CC} = \text{MIN.}, I_{IN} = -18\text{mA}$  |   |                 | -1.5   | Volts         |
| $I_{IL}$   | Input LOW Current                        | $V_{CC} = \text{MAX.}, V_{IN} = 0.5\text{V}$   | $D_{0-3}$   |                 | -0.360 | mA            |
|            |  |  | $I_{0-4}, \bar{R}\bar{E}, \bar{I}\bar{E}\bar{N},$<br>$\bar{C}\bar{P}, \bar{O}\bar{E}$ |                 | -0.702 |               |
|            |  |  | $\bar{C}\bar{C}$  |                 | -0.657 |               |
|            |  |  | $C_i$   |                 | -2.31  |               |
|            |  |  | $C_n$   |                 | -3.25  |               |
| $I_{IH}$   | Input HIGH Current                       | $V_{CC} = \text{MAX.}, V_{IN} = 2.7\text{V}$   | $D_{0-3}$   |                 | 20     | $\mu\text{A}$ |
|            |  |  | $I_{0-4}, \bar{R}\bar{E}, \bar{I}\bar{E}\bar{N},$<br>$\bar{C}\bar{P}, \bar{O}\bar{E}$ |                 | 40     |               |
|            |  |  | $\bar{C}\bar{C}$  |                 | 50     |               |
|            |  |  | $C_i$   |                 | 90     |               |
|            |  |  | $C_n$   |                 | 250    |               |
| $I_I$      | Input HIGH Current                       | $V_{CC} = \text{MAX.}, V_{IN} = 5.5\text{V}$   |   |                 | 1.0    | mA            |
| $I_{SC}$   | Output Short Circuit Current<br>(Note 3) | $V_{CC} = \text{MAX.}$   | -30   |                 | -85    | mA            |
| $I_{OZL}$  | Output OFF Current                       | $V_{CC} = \text{MAX.}, \bar{O}\bar{E} = 2.4\text{V}$   | $V_{OUT} = 0.5\text{V}$   |                 | -50    | $\mu\text{A}$ |
| $I_{OZH}$  |  |  | $V_{OUT} = 2.4\text{V}$   |                 | 50     |               |
| $I_{CC}$   | Power Supply Current<br>(Note 5)         | $V_{CC} = 5.0\text{V}$   | $T_A = 25^\circ\text{C}$  | 150             | 205    | mA            |
|            |  |  | $T_C = -55$ to $+125^\circ\text{C}$   |                 | 239    |               |
|            |  | $V_{CC} = \text{MAX.}$   | $T_C = +125^\circ\text{C}$  |                 | 170    |               |
|            |  |  | $T_A = 0$ to $70^\circ\text{C}$   |                 | 220    |               |
|            |  |  | $T_A = 70^\circ\text{C}$  |                 | 185    |               |

- Notes: 1. For conditions shown as MIN. or MAX., use the appropriate value specified under Electrical Characteristics for the applicable device type.  
2. Typical limits are at  $V_{CC} = 5.0\text{V}$ ,  $25^\circ\text{C}$  ambient and maximum loading.  
3. Not more than one output should be shorted at a time. Duration of the short circuit test should not exceed one second.  
4. These input levels provide no guaranteed noise immunity and should only be tested in a static, noise-free environment.  
5. Minimum  $I_{CC}$  is at maximum temperature.

## Am2930 SWITCHING CHARACTERISTICS

Tables A, B, C and D define the timing characteristics of the Am2930. Measurements are made at 1.5V with  $V_{IL} = 0V$  and  $V_{IH} = 3.0V$ . For three-state disable tests,  $C_L = 5.0pF$  and measurement is to 0.5V change on output voltage level.

## I. Typical Room Temperature Performance.

$$V_{CC} = 5.0V, T_A = 25^\circ C$$

**TABLE IA**  
Clock Characteristics.

|                         |      |
|-------------------------|------|
| Minimum Clock LOW Time  | 18ns |
| Minimum Clock HIGH Time | 20ns |

**TABLE IB**  
Output Enable/Disable Times.

All in ns.

$C_L = 5.0pF$  for output disable tests.

| From                        | To | Enable | Disable |
|-----------------------------|----|--------|---------|
| $\overline{OE}$             | Y  | 18     | 17      |
| $\overline{CC}$<br>(Note 1) | Y  | 39     | 27      |
| $I_{4-0}$<br>(Note 1)       | Y  | 57     | 41      |

**TABLE IC**  
Combinational Propagation Delays.

All in ns.


Outputs fully loaded.  $C_L = 50pF$ .

| From Input \ To Output | Y  | $\overline{G}, \overline{P}$ | $C_{n+4}$ | $C_{i+4}$<br>$I_4=L$ | $C_{i+4}$<br>$I_4=H$ | Full | Empty |
|------------------------|----|------------------------------|-----------|----------------------|----------------------|------|-------|
| $I_{4-0}$              | 61 | 50                           | 57        | 61                   | 69                   | 52   | —     |
| $\overline{CC}$        | 46 | 32                           | 39        | —                    | 53                   | 29   | —     |
| $C_n$                  | 25 | —                            | 17        | —                    | 32                   | —    | —     |
| $C_i$                  | —  | —                            | —         | 14                   | 14                   | —    | —     |
| CP                     | 52 | 40                           | 46        | 33                   | 58                   | 40   | 40    |
| D                      | 37 | 23                           | 30        | —                    | 43                   | —    | —     |
| $\overline{IEN}$       | —  | —                            | —         | —                    | —                    | 27   | —     |

Note 1: "Suspend" instruction.

**TABLE ID**  
Set-up and Hold Times. All in ns.

All relative to clock  
LOW-to-HIGH transition.

| Input  | CP:  |           |
|--|---|-----------|
|  | Set-up Time   | Hold Time |
| $I_{4-0}$  | 68  | 0         |
| $\overline{CC}$  | 53  | 0         |
| $\overline{IEN}$                                       | 39  | 0         |
| $C_n$  | 28  | 0         |
| $C_i$  | 18  | 3         |
| D ( $\overline{RE} = L$ ,<br>$I_{4-0} = 0-8$ or 10-15) | 14  | 0         |
| D (All other conditions)                               | 44  | 0         |
| $\overline{RE}$  | 13  | 2         |

## II. Guaranteed Performance Over Commercial Operating Range.

$$V_{CC} = 4.75 \text{ to } 5.25V, T_A = 0 \text{ to } 70^\circ C$$

**TABLE IIA**  
Clock Characteristics.

|                         |      |
|-------------------------|------|
| Minimum Clock LOW Time  | 31ns |
| Minimum Clock HIGH Time | 33ns |

**TABLE IIB**  
Output Enable/Disable Times.

All in ns.

$C_L = 5.0pF$  for output disable tests.

| From                        | To | Enable | Disable |
|-----------------------------|----|--------|---------|
| $\overline{OE}$             | Y  | 27     | 26      |
| $\overline{CC}$<br>(Note 1) | Y  | 55     | 37      |
| $I_{4-0}$<br>(Note 1)       | Y  | 80     | 55      |

**TABLE IIC**  
Combinational Propagation Delays.

All in ns.


Outputs fully loaded.  $C_L = 50pF$ .

| From Input \ To Output | Y  | $\overline{G}, \overline{P}$ | $C_{n+4}$ | $C_{i+4}$<br>$I_4=L$ | $C_{i+4}$<br>$I_4=H$ | Full | Empty |
|------------------------|----|------------------------------|-----------|----------------------|----------------------|------|-------|
| $I_{4-0}$              | 81 | 67                           | 77        | 80                   | 91                   | 69   | —     |
| $\overline{CC}$        | 63 | 45                           | 55        | —                    | 72                   | 42   | —     |
| $C_n$                  | 32 | —                            | 25        | —                    | 45                   | —    | —     |
| $C_i$                  | —  | —                            | —         | 22                   | 22                   | —    | —     |
| CP                     | 69 | 53                           | 61        | 43                   | 78                   | 55   | 55    |
| D                      | 49 | 33                           | 40        | —                    | 59                   | —    | —     |
| $\overline{IEN}$       | —  | —                            | —         | —                    | —                    | 40   | —     |

Note 1: "Suspend" instruction.

**TABLE IID**  
Set-up and Hold Times. All in ns.

All relative to clock  
LOW-to-HIGH transition.

| Input  | CP:  |           |
|--|---|-----------|
|  | Set-up Time   | Hold Time |
| $I_{4-0}$  | 114   | 0         |
| $\overline{CC}$  | 75  | 0         |
| $\overline{IEN}$                                       | 55  | 0         |
| $C_n$  | 43  | 0         |
| $C_i$  | 32  | 5         |
| D ( $\overline{RE} = L$ ,<br>$I_{4-0} = 0-8$ or 10-15) | 25  | 2         |
| D (All other conditions)                               | 66  | 2         |
| $\overline{RE}$  | 24  | 4         |

## III. Guaranteed Performance Over Military Operating Range.

$$V_{CC} = 4.5 \text{ to } 5.5V, T_C = -55 \text{ to } +125^\circ C$$

**TABLE IIIA**  
Clock Characteristics.

|                         |      |
|-------------------------|------|
| Minimum Clock LOW Time  | 35ns |
| Minimum Clock HIGH Time | 35ns |

**TABLE IIIB**  
Output Enable/Disable Times.

All in ns.

$C_L = 5.0pF$  for output disable tests.

| From                        | To | Enable | Disable |
|-----------------------------|----|--------|---------|
| $\overline{OE}$             | Y  | 32     | 31      |
| $\overline{CC}$<br>(Note 1) | Y  | 60     | 42      |
| $I_{4-0}$<br>(Note 1)       | Y  | 85     | 60      |

**TABLE IIIC**  
Combinational Propagation Delays.

All in ns.


Outputs fully loaded.  $C_L = 50pF$ .

| From Input \ To Output | Y  | $\overline{G}, \overline{P}$ | $C_{n+4}$ | $C_{i+4}$<br>$I_4=L$ | $C_{i+4}$<br>$I_4=H$ | Full | Empty |
|------------------------|----|------------------------------|-----------|----------------------|----------------------|------|-------|
| $I_{4-0}$              | 88 | 74                           | 82        | 87                   | 97                   | 78   | —     |
| $\overline{CC}$        | 68 | 52                           | 60        | —                    | 78                   | 47   | —     |
| $C_n$                  | 37 | —                            | 30        | —                    | 46                   | —    | —     |
| $C_i$                  | —  | —                            | —         | 23                   | 23                   | —    | —     |
| CP                     | 74 | 58                           | 66        | 48                   | 84                   | 60   | 60    |
| D                      | 55 | 38                           | 45        | —                    | 65                   | —    | —     |
| $\overline{IEN}$       | —  | —                            | —         | —                    | —                    | 45   | —     |

Note 1: "Suspend" instruction.

**TABLE IIID**  
Set-up and Hold Times. All in ns.

All relative to clock  
LOW-to-HIGH transition.

| Input  | CP:  |           |
|--|---|-----------|
|  | Set-up Time   | Hold Time |
| $I_{4-0}$  | 124   | 0         |
| $\overline{CC}$  | 80  | 0         |
| $\overline{IEN}$                                       | 69  | 0         |
| $C_n$  | 52  | 0         |
| $C_i$  | 37  | 5         |
| D ( $\overline{RE} = L$ ,<br>$I_{4-0} = 0-8$ or 10-15) | 30  | 2         |
| D (All other conditions)                               | 72  | 2         |
| $\overline{RE}$  | 29  | 4         |



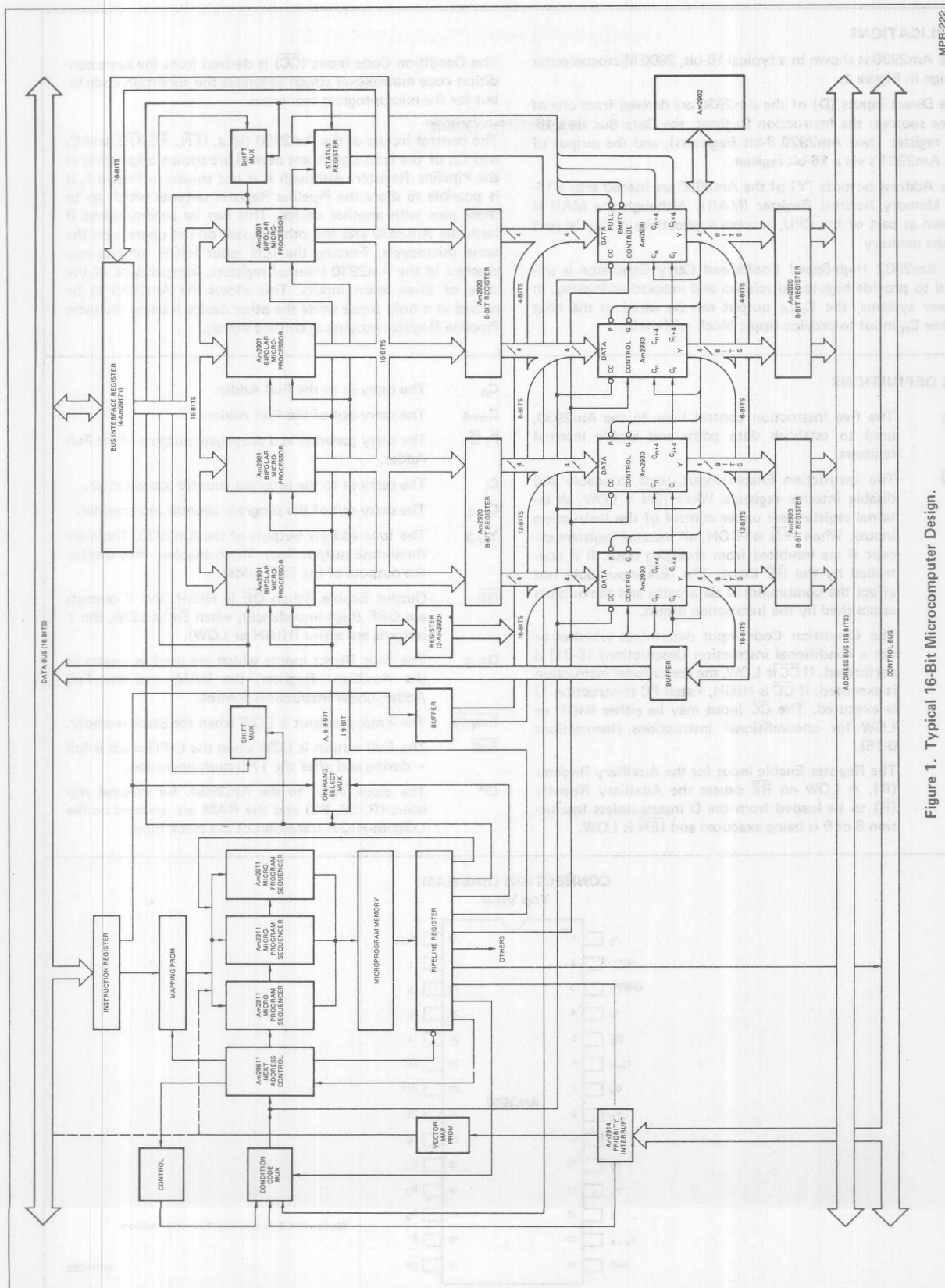


Figure 1. Typical 16-Bit Microcomputer Design.



## APPLICATIONS

The Am2930 is shown in a typical 16-bit, 2900 Microcomputer design in Figure 1.

The Direct inputs (D) of the Am2930 are derived from one of three sources: the Instruction Register, the Data Bus via a 16-bit register (two Am2920 8-bit Registers), and the output of the Am2901's via a 16-bit register.

The Address outputs (Y) of the Am2930 are loaded into a 16-bit Memory Address Register (MAR). Although the MAR is shown as part of the CPU, in some applications it may be part of the memory.

An Am2902 High-Speed Lookahead Carry Generator is utilized to provide high-speed relative and indexed addressing. In slower systems, the  $C_{n+4}$  output can be wired to the next higher  $C_n$  input to provide ripple block arithmetic.

The Condition Code input ( $\overline{CC}$ ) is derived from the same condition code multiplexer which generates the condition code input for the microprogram sequencer.

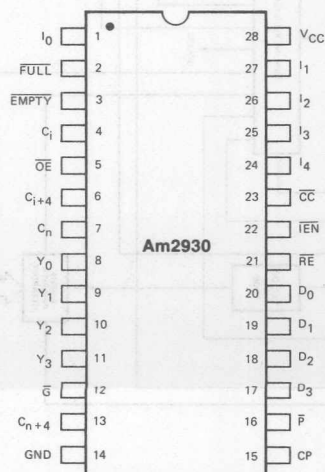
The control inputs of the Am2930 ( $I_{0-4}$ ,  $\overline{IEN}$ ,  $\overline{RE}$ ,  $\overline{OE}$ , and  $C_i$  and  $C_n$  of the least significant device) are shown originating at the Pipeline Register. Although it is not shown in Figure 1, it is possible to share the Pipeline Register outputs which go to these pins with another device. This can be accomplished if both the Am2930 and the other device do not operate on the same microcycle. Forcing the  $\overline{IEN}$  input HIGH inhibits any changes in the Am2930 internal registers, independent of the state of these seven inputs. This allows the Am2930 to be placed in a hold mode while the other device is using the same Pipeline Register outputs as control signals.

## PIN DEFINITIONS

|                  |   |
|------------------|---|
| $I_{0-4}$        | The five Instruction control lines to the Am2930, used to establish data paths and enable internal registers.   |
| $\overline{IEN}$ | The Instruction Enable Input, used to enable and disable internal registers. When $\overline{IEN}$ is LOW, all internal registers are under control of the Instruction inputs. When $\overline{IEN}$ is HIGH, all internal registers except R are inhibited from changing state. R is controlled by the $\overline{RE}$ input. The $\overline{IEN}$ input does not affect the combinatorial data paths and the outputs established by the Instruction inputs. |
| $\overline{CC}$  | The Condition Code input determines whether or not a conditional instruction (Instructions 16-31) is performed. If $\overline{CC}$ is LOW, the conditional instruction is executed. If $\overline{CC}$ is HIGH, Fetch PC (Instruction 1) is executed. The $\overline{CC}$ input may be either HIGH or LOW for unconditional instructions (Instructions 0-15).   |
| $\overline{RE}$  | The Register Enable input for the Auxiliary Register (R). A LOW on $\overline{RE}$ causes the Auxiliary Register (R) to be loaded from the D inputs unless Instruction 8 or 9 is being executed and $\overline{IEN}$ is LOW.  |

|                              |   |
|------------------------------|---|
| $C_n$                        | The carry-in to the Full Adder.   |
| $C_{n+4}$                    | The carry-out of the Full Adder.  |
| $\overline{P}, \overline{G}$ | The carry generate and propagate outputs of the Full Adder.   |
| $C_i$                        | The carry-in to the program counter incrementer.  |
| $C_{i+4}$                    | The carry-out of the program counter incrementer.   |
| $Y_{0-3}$                    | The four address outputs of the Am2930. These are three-state output lines. When enabled, they display the outputs of the Full Adder.                     |
| $\overline{OE}$              | Output Enable. When $\overline{OE}$ is HIGH, the Y outputs are OFF (high-impedance); when $\overline{OE}$ is LOW, the Y outputs are active (HIGH or LOW). |
| $D_{0-3}$                    | The four Direct inputs which are used as inputs to the Auxiliary Register, the RAM, and the Full Adder, under instruction control.                        |
| Empty                        | The Empty output is LOW when the Stack is empty.  |
| Full                         | The Full output is LOW when the LIFO stack is full — during and after the 17th push operation.  |
| CP                           | The clock input to the Am2930. All internal registers (R, SP, PC) and the RAM are updated on the LOW-to-HIGH transition of the clock input.               |

CONNECTION DIAGRAM  
Top View

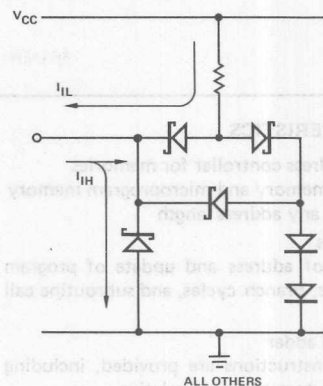
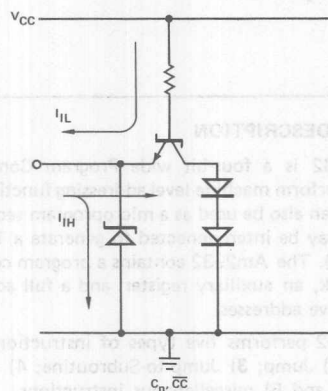


Note: Pin 1 is marked for orientation.

MPR-225

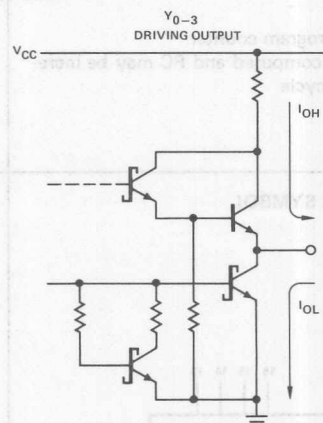
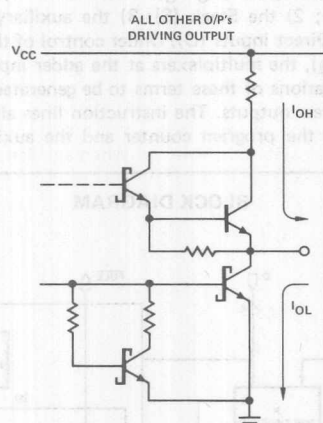
## INPUT/OUTPUT CIRCUIT CURRENT INTERFACE

## DRIVEN INPUTS



Note:  $C_i$  input is connected to both configurations in parallel.

## DRIVING OUTPUTS



Note: Actual current flow direction shown.

## ORDERING INFORMATION

Order the part number according to the table below to obtain the desired package, temperature range, and screening level.

| Order Number | Package Type<br>(Note 1) | Operating Range<br>(Note 2) | Screening Level<br>(Note 3)                          |
|--------------|--------------------------|-----------------------------|--|
| AM2930PC     | P-28                     | C                           | C-1  |
| AM2930DC     | D-28                     | C                           | C-1  |
| AM2930DC-B   | D-28                     | C                           | B-2 (Note 4)   |
| AM2930DM     | D-28                     | M                           | C-3  |
| AM2930DM-B   | D-28                     | M                           | B-3  |
| AM2930FM     | F-28-2                   | M                           | C-3  |
| AM2930FM-B   | F-28-2                   | M                           | B-3  |
| AM2930XC     | Dice                     | C                           | Visual inspection<br>to MIL-STD-883<br>Method 2010B. |
| AM2930XM     | Dice                     | M                           |  |

Notes: 1. P = Molded DIP, D = Hermetic DIP, F = Flat Pak. Number following letter is number of leads. See Appendix B for detailed outline.

Where Appendix B contains several dash numbers, any of the variations of the package may be used unless otherwise specified.

2. C = 0 to 70°C,  $V_{CC}$  = 4.75 to 5.25V; M = -55 to +125°C,  $V_{CC}$  = 4.50 to 5.50V

3. See Appendix A for details of screening. Levels C-1 and C-3 conform to MIL-STD-883, Class C. Level B-3 conforms to MIL-STD-883, Class B.

4. 96 hour burn-in.

# Am2932

- Powerful, 4-bit slice address controller for memories  
Useful with both main memory and microprogram memory  
Expandable to generate any address length
- Executes 16 instructions  
Automatic generation of address and update of program counter for fetch cycles, branch cycles, and subroutine call and return
- Contains cascadable full adder  
Eight relative address instructions are provided, including jump relative and jump-to-subroutine relative
- Seventeen-level push/pop stack  
On-chip storage of subroutine return addresses nested up to 17 levels deep
- Separate incrementer for program counter  
A relative address may be computed and PC may be incremented by one on a single cycle

The Am2932 is a four-bit wide Program Control Unit intended to perform machine level addressing functions, although the device can also be used as a microprogram sequencer. Four Am2932s may be interconnected to generate a 16-bit address (64K words). The Am2932 contains a program counter, a subroutine stack, an auxiliary register, and a full adder for computing relative addresses.

There are four sources of data for the adder which generates the Address outputs ( $Y_0$ - $Y_3$ ). These are: 1) the Program Counter(PC); 2) the Stack (S); 3) the auxiliary Register(R); and 4) the Direct inputs (D). Under control of the Instruction inputs ( $I_0$ - $I_3$ ), the multiplexers at the adder inputs allow various combinations of these terms to be generated at the three-state Y address outputs. The instruction lines also control the updating of the program counter and the auxiliary register.

Pin diagram of the Am2932 4-bit parallel adder. The chip has 16 pins. Pin 1 is  $I_0$ , Pin 2 is FULL (output), Pin 3 is  $C_i$ , Pin 4 is  $C_{i+4}$ , Pin 5 is  $C_n$ , Pin 6 is  $Y_0$ , Pin 7 is  $Y_1$ , Pin 8 is  $Y_2$ , Pin 9 is  $Y_3$ , Pin 11 is CP, Pin 12 is  $C_{n+4}$ , Pin 13 is  $I_3$ , Pin 14 is  $D_3$ , Pin 15 is  $D_1$ , Pin 16 is  $D_0$ . Pins 17, 18, and 19 are unconnected.

V<sub>CC</sub> = Pin 20  
GND = Pin 10

[illegible]

## ARCHITECTURE OF THE Am2931/32

The Am2932 is a bipolar Program Control Unit intended for use in high-speed microprocessor applications. The device is a cascadable, four-bit slice such that three devices allow addressing of up to 4K words of memory and four devices allow addressing of up to 64K words of memory.

As shown in the Block Diagram, the device consists of the following:

- 1) A full adder with input multiplexers
- 2) A Program Counter Register with an incrementer and an input multiplexer
- 3) A 17 x 4 Last-In, First-Out (LIFO) stack consisting of an input multiplexer, a 17 x 4 RAM, and a Stack Pointer
- 4) An auxiliary register with an input multiplexer
- 5) An instruction decoder
- 6) Four 3-state output buffers on the address outputs

The following paragraphs describe each of these blocks in detail.

### Full Adder

The Full Adder is a binary device with full lookahead carry logic for high-speed addition. The carry output ( $C_{n+4}$ ) can be connected to the next higher  $C_n$  to provide ripple block arithmetic. The carry input to the adder ( $C_n$ ) is internally inhibited during those instructions which do not require an addition to be performed. For these instructions, the data is passed directly through the adder, independent of the state of  $C_n$ .

The multiplexers at the A and B inputs of the adder are controlled by the Instruction decoder which selects the appropriate adder inputs for the selected instruction.

### Program Counter

The program counter consists of a register preceded by an incrementer. The Program Counter Register (PC) is a four-bit, edge-triggered, D-type register which is loaded from the incrementer output on the LOW-to-HIGH transition of the clock input (CP) at the end of every instruction.

The incrementer utilizes full lookahead logic for high speed. For cascading devices, the carry output of the incrementer ( $C_{i+4}$ ) is connected to the incrementer carry input ( $C_i$ ) of the next higher device. The output of the incrementer, which is loaded into the PC, is equal to the incrementer input plus  $C_i$ . Therefore, it is possible to control the entire cascaded incrementer from the  $C_i$  input of the least significant device; a LOW on the  $C_i$  input of the least significant device will simply pass the data from the multiplexer output to the inputs of PC; a HIGH will cause the outputs of the multiplexer to be incremented before they are loaded into PC. During the suspend

instruction the  $C_i$  input is internally inhibited; therefore, data is passed from the multiplexer output to the PC without incrementing. The multiplexer selects the input to the incrementer from either PC or the output of the Full Adder, depending upon the instruction being executed. During the Jump, Jump-to-Subroutine, and Return instructions, the multiplexer chooses the Full Adder outputs as the input to the incrementer. The Full Adder output is also selected for the Reset instruction. For all other instructions, the PC is selected as the input to the incrementer.

### 17 x 4 LIFO Stack

The 17 x 4 LIFO stack consists of a multiplexer, a 17 x 4 RAM, and a Stack Pointer (SP) which address the words in the RAM.

The SP always points to the last word written into the RAM (Top of the Stack). The Top of the Stack (S) is available at the output of the RAM.

Data is pushed onto the Top of the Stack from either D or PC. It is written into memory location  $SP+1$ . The SP is incremented on the LOW-to-HIGH clock transition at the end of the cycle so that it still points to the last data written into the RAM.

For a Pop operation, the contents of the RAM are not changed, but the SP is decremented at the end of the cycle so that it then points to the new Top of the Stack.

The SP is an up/down counter which changes state on the LOW-to-HIGH transition of the Clock input. It is internally prevented from incrementing when the stack is full and from decrementing when the Stack is empty. When the Stack is full, the RAM write circuitry is also inhibited.

The active LOW Full output ( $\overline{FULL}$ ) is LOW either when the stack is full or when the current instruction being executed will fill the stack (during and after the 17th Push).

### Auxiliary Register (R)

The Auxiliary Register (R) can be loaded from either the Direct inputs (D) or the output of the Full Adder. It is loaded on the LOW-to-HIGH transition of the clock input (CP) if the Instruction inputs call for it to be loaded.

### Instruction Decoder

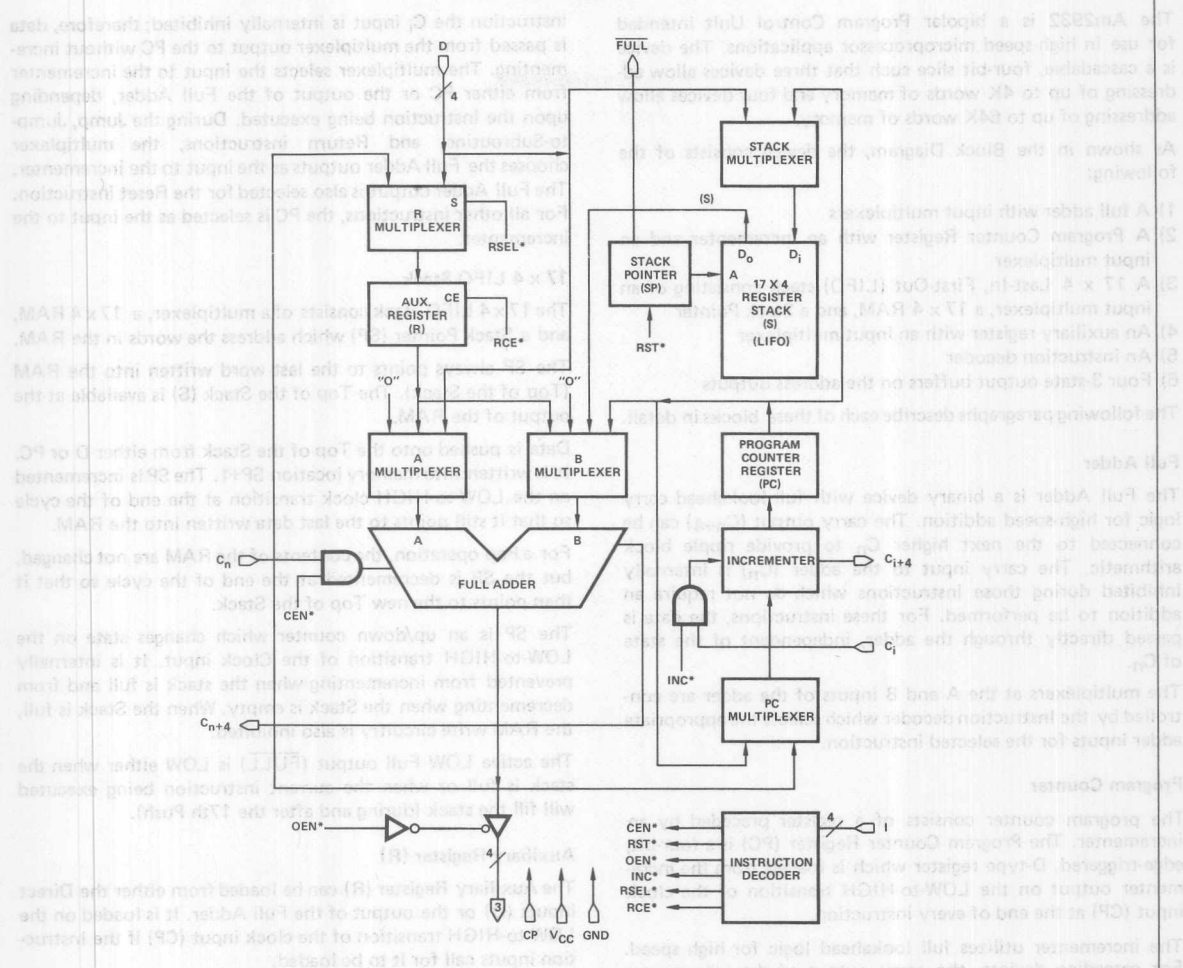
The Instruction Decoder generates the signals necessary to establish the data paths and to enable the loading of the PC, R, SP, and RAM.

### Output Buffers

The Address outputs ( $Y_0$ - $Y_3$ ) are three-state drivers which may be disabled under Instruction control.



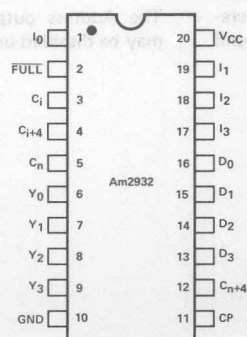
## BLOCK DIAGRAM



BLI-096

## CONNECTION DIAGRAM

## Top View



BLI-097

Note: Pin 1 is marked for orientation.



TABLE I — Am2932 INSTRUCTION SET

| Instruction Number | I <sub>3</sub> | I <sub>2</sub> | I <sub>1</sub> | I <sub>0</sub> | Mnemonic | Instruction | Y <sub>0</sub> -Y <sub>3</sub> | Next State (after CP) — Note 2      |    |             |       |  |
|--------------------|----------------|----------------|----------------|----------------|----------|-------------|--------------------------------|-------------------------------------|----|-------------|-------|--|
|                    |                |                |                |                |          |             |                                | PC                                  | R  | RAM         | SP    |  |
| 0                  | L              | L              | L              | L              | PRST     | RESET       | "0"                            | "0"+C <sub>i</sub>                  | —  | —           | Reset |  |
| 1                  | L              | L              | L              | H              | PSUS     | SUSPEND     | Z (Note 1)                     | —                                   | —  | —           | —     |  |
| 2                  | L              | L              | H              | L              | PSHD     | PUSH D      | PC                             | PC+C <sub>i</sub>                   | —  | D→Loc SP+1  | SP+1  |  |
| 3                  | L              | L              | H              | H              | POPS     | POP S       | S                              | PC+C <sub>i</sub>                   | —  | —           | SP-1  |  |
| 4                  | L              | H              | L              | L              | FPC      | FETCH PC    | PC                             | PC+C <sub>i</sub>                   | —  | —           | —     |  |
| 5                  | L              | H              | L              | H              | JMPD     | JUMP D      | D                              | D+C <sub>i</sub>                    | —  | —           | —     |  |
| 6                  | L              | H              | H              | L              | PSHP     | PUSH PC     | PC                             | PC+C <sub>i</sub>                   | —  | PC→Loc SP+1 | SP+1  |  |
| 7                  | L              | H              | H              | H              | RTS      | RETURN S    | S                              | S+C <sub>i</sub>                    | —  | —           | SP-1  |  |
| 8                  | H              | L              | L              | L              | FR       | FETCH R     | R                              | PC+C <sub>i</sub>                   | —  | —           | —     |  |
| 9                  | H              | L              | L              | H              | FPR      | FETCH PC+R  | PC+R+C <sub>n</sub>            | PC+C <sub>i</sub>                   | —  | —           | —     |  |
| 10                 | H              | L              | H              | L              | FPLR     | FETCH PC→R  | PC                             | PC+C <sub>i</sub>                   | PC | —           | —     |  |
| 11                 | H              | L              | H              | H              | JMPR     | JUMP R      | R                              | R+C <sub>i</sub>                    | —  | —           | —     |  |
| 12                 | H              | H              | L              | L              | JPPR     | JUMP PC+R   | PC+R+C <sub>n</sub>            | PC+R+C <sub>n</sub> +C <sub>i</sub> | —  | —           | —     |  |
| 13                 | H              | H              | L              | H              | JSBR     | JSB R       | R                              | R+C <sub>i</sub>                    | —  | PC→Loc SP+1 | SP+1  |  |
| 14                 | H              | H              | H              | L              | JSPR     | JSB PC+R    | PC+R+C <sub>n</sub>            | PC+R+C <sub>n</sub> +C <sub>i</sub> | —  | PC→Loc SP+1 | SP+1  |  |
| 15                 | H              | H              | H              | H              | PLDR     | LOAD R      | PC                             | PC+C <sub>i</sub>                   | D  | —           | —     |  |

Notes: 1. Z = High impedance state (outputs "OFF")  
2. — = No change

PC — Program Counter      SP — Stack Pointer  
R — Auxiliary Register      D — Direct Inputs

2

### Am2932 INSTRUCTION SET

The Am2932 Instruction set can be divided into five types of instructions. These are:

- Fetches
- Jumps
- Jumps-to-Subroutine
- Return-from-Subroutine
- Miscellaneous Instructions

The following paragraphs describe each of these types in detail.

#### Fetches

As can be seen from Table I, there are four Fetch instructions (Instructions 4, 8, 9, 10). Under control of the Instructions inputs, the desired function is placed at the Y outputs. For all Fetch instructions, PC is incremented if C<sub>i</sub> of the least significant device is HIGH. For Instruction 10 R is loaded with PC. The RAM and Stack Pointer are not changed during a Fetch instruction.

#### Jumps

There are three Jump instructions (Instructions 5, 11, 12). Under control of the Instruction inputs, the desired function is placed at the Y outputs. Additionally, the desired function is incremented if C<sub>i</sub> of the least significant device is HIGH and loaded into PC. The RAM, Stack Pointer and R are not changed during these instructions.

#### Jumps-to-Subroutine

There are two Jump-to-Subroutine instructions (Instructions 13 and 14). Under control of the Instruction inputs, the desired function is placed on the Y outputs. On the rising edge of the clock the data on the Y outputs is incremented and loaded into PC, PC is loaded into the RAM at location SP+1; and SP is incremented.

During these instructions, R is not changed.

#### Return-from-Subroutine (Instruction 7)

Under control of the instruction inputs, S is placed at the Y

outputs. Additionally, S is incremented and loaded into PC and SP is decremented at the end of the cycle (on the rising edge of the clock).

During this instruction, R is not changed.

#### Miscellaneous Instructions

Each of the nine miscellaneous instructions is described individually.

#### Reset (Instruction 0)

The Reset instruction forces the Y outputs to zero, loads either zero or one into PC, depending upon the C<sub>i</sub> input of the least significant device, and resets SP. The RAM and R are unchanged.

#### Load R (Instruction 15)

This instruction loads the data on the D inputs into R. PC is either incremented or held depending upon C<sub>i</sub> of the least significant device. The SP and RAM are not changed.

#### Push PC (Instruction 6)

This instruction is the same as Fetch PC except that PC is loaded into RAM and SP is incremented at the end of the cycle; i.e., the current PC is Pushed onto the stack.

#### Push D (Instruction 2)

This instruction is the same as Fetch PC except that D is loaded into the RAM and SP is incremented at the end of the cycle; i.e., external data is Pushed onto the stack.

#### Pop S (Instruction 3)

This instruction places the Top of the Stack (S) at the Y outputs and decrements SP at the end of the cycle. The PC is incremented if the C<sub>i</sub> input of the least significant device is HIGH. R is not changed.

#### Suspend (Instruction 1)

The Suspend instruction inhibits any change in PC, SP, R and RAM and forces the Y outputs into the high impedance state.

## Am2932

**MAXIMUM RATINGS** (Above which the useful life may be impaired)

|   |                        |
|---|------------------------|
| Storage Temperature                                 | -65 to +150°C          |
| Temperature (Ambient) Under Bias                    | -55 to +125°C          |
| Supply Voltage to Ground Potential                  | -0.5 to +7.0V          |
| DC Voltage Applied to Outputs for High Output State | -0.5V to $V_{CC}$ max. |
| DC Input Voltage                                    | -0.5 to +5.5V          |
| DC Output Current, Into Outputs                     | 30mA                   |
| DC Input Current                                    | -30 to +5.0mA          |

**OPERATING RANGE**

| Part Number  | Temperature                         | $V_{CC}$       |
|--------------|-------------------------------------|----------------|
| Am2932PC, DC | $T_A = 0$ to $70^\circ\text{C}$     | 4.75V to 5.25V |
| Am2932DM     | $T_C = -55$ to $+125^\circ\text{C}$ | 4.50V to 5.50V |

**DC CHARACTERISTICS OVER OPERATING RANGE**

| Parameters | Description                           | Test Conditions (Note 1)  | Min | Typ<br>(Note 2) | Max    | Units         |
|------------|---------------------------------------|---|-----|-----------------|--------|---------------|
| $V_{OH}$   | Output HIGH Voltage                   | $V_{CC} = \text{MIN.}$ ,<br>$V_{IN} = V_{IL}$ or $V_{IH}$<br>$Y_0, Y_1, Y_2, Y_3$<br>$G, C_{n+4},$<br>$C_{i+4}$<br>$I_{OH} = -1.6\text{mA}$ | 2.4 |                 |        | Volts         |
|            |                                       | FULL<br>$I_{OH} = -1.2\text{mA}$  | 2.4 |                 |        |               |
| $V_{OL}$   | Output LOW Voltage                    | $V_{CC} = \text{MIN.}$ ,<br>$V_{IN} = V_{IL}$ or $V_{IH}$<br>$Y_0, Y_1, Y_2, Y_3$<br>$I_{OL} = 20\text{mA}$<br>(COM'L)                      |     |                 | 0.5    | Volts         |
|            |                                       | $C_{n+4},$<br>$C_{i+4}$<br>$I_{OL} = 16\text{mA}$   |     |                 | 0.5    |               |
|            |                                       | FULL<br>$I_{OL} = 12\text{mA}$  |     |                 | 0.5    |               |
|            |                                       |   |     |                 |        |               |
| $V_{IH}$   | Input HIGH Level (Note 4)             |   | 2.0 |                 |        | Volts         |
| $V_{IL}$   | Input LOW Level (Note 4)              |   |     |                 | 0.8    | Volts         |
| $V_I$      | Input Clamp Voltage                   | $V_{CC} = \text{MIN.}$ , $I_{IN} = -18\text{mA}$  |     |                 | -1.5   | Volts         |
| $I_{IL}$   | Input LOW Current                     | $V_{CC} = \text{MAX.}$ , $V_{IN} = 0.5\text{V}$<br>$D_{0-3}$  |     |                 | -0.360 | mA            |
|            |                                       | $I_{0-3}, \text{CP}$  |     |                 | -0.702 |               |
|            |                                       | $C_i$   |     |                 | -2.0   |               |
|            |                                       | $C_n$   |     |                 | -3.69  |               |
| $I_{IH}$   | Input HIGH Current                    | $V_{CC} = \text{MAX.}$ , $V_{IN} = 2.7\text{V}$<br>$D_{0-3}$  |     |                 | 20     | $\mu\text{A}$ |
|            |                                       | $I_{0-3}, \text{CP}$  |     |                 | 40     |               |
|            |                                       | $C_i$   |     |                 | 90     |               |
|            |                                       | $C_n$   |     |                 | 250    |               |
| $I_I$      | Input HIGH Current                    | $V_{CC} = \text{MAX.}$ , $V_{IN} = 5.5\text{V}$   |     |                 | 1.0    | mA            |
| $I_{SC}$   | Output Short Circuit Current (Note 3) | $V_{CC} = \text{MAX.}$  | -30 |                 | -85    | mA            |
| $I_{OZL}$  | Output OFF Current                    | $V_{CC} = \text{MAX.}$ , $\overline{OE} = 2.4\text{V}$<br>$V_{OUT} = 0.5\text{V}$   |     |                 | -50    | $\mu\text{A}$ |
| $I_{OZH}$  |                                       |   |     |                 | 50     |               |
| $I_{CC}$   | Power Supply Current (Note 5)         | $V_{CC} = 5.0\text{V}$<br>$T_A = 25^\circ\text{C}$  |     | 128             | 176    | mA            |
|            |                                       | $T_C = -55$ to $+125^\circ\text{C}$   |     |                 | 210    |               |
|            |                                       | $T_C = +125^\circ\text{C}$  |     |                 | 145    |               |
|            |                                       | $T_A = 0$ to $70^\circ\text{C}$   |     |                 | 190    |               |
|            |                                       | $T_A = 70^\circ\text{C}$  |     |                 | 160    |               |

- Notes: 1. For conditions shown as MIN. or MAX., use the appropriate value specified under Electrical Characteristics for the applicable device type.  
2. Typical limits are at  $V_{CC} = 5.0\text{V}$ ,  $25^\circ\text{C}$  ambient and maximum loading.  
3. Not more than one output should be shorted at a time. Duration of the short circuit test should not exceed one second.  
4. These input levels provide no guaranteed noise immunity and should only be tested in a static, noise-free environment.  
5. Minimum  $I_{CC}$  is at maximum temperature.

## Am2932 SWITCHING CHARACTERISTICS

Tables A, B, C and D define the timing characteristics of the Am2932. Measurements are made at 1.5V with  $V_{IL} = 0V$  and  $V_{IH} = 3.0V$ . For three-state disable tests,  $C_L = 5.0pF$  and measurement is to 0.5V change on output voltage level.

## I. Typical Room Temperature Performance.

$$V_{CC} = 5.0V, T_A = 25^\circ C$$

**TABLE IA**  
Clock Characteristics.

|                         |      |
|-------------------------|------|
| Minimum Clock LOW Time  | 18ns |
| Minimum Clock HIGH Time | 20ns |

**TABLE IB**  
Output Enable/Disable Times.

All in ns.  
 $C_L = 5.0pF$  for output disable tests.

| From      | To | Enable | Disable |
|-----------|----|--------|---------|
| $I_{3-0}$ | Y  | 57     | 41      |

**TABLE IC**  
Combinational Propagation Delays.

All in ns.  
Outputs fully loaded.  $C_L = 50pF$ .

| To Output  | Y  | $C_{n+4}$ | $C_{i+4}$<br>(Note 1) | $C_{i+4}$<br>(Note 2) | Full |
|------------|----|-----------|-----------------------|-----------------------|------|
| From Input |    |           |                       |                       |      |
| $I_{3-0}$  | 61 | 57        | 69                    | 61                    | 52   |
| $C_n$      | 25 | 17        | 32                    | —                     | —    |
| $C_i$      | —  | —         | 14                    | 14                    | —    |
| CP         | 52 | 46        | 58                    | 33                    | 40   |
| D          | 29 | —         | 37                    | —                     | —    |

Notes: 1. Instructions 5, 7, 11, 12, 13, 14.  
2. All instructions except 5, 7, 11, 12, 13, 14.

**TABLE ID**  
Set-up and Hold Times. All in ns.

All relative to clock  
LOW-to-HIGH transition.

| Input     | CP:         |           |
|-----------|-------------|-----------|
|           | Set-up Time | Hold Time |
| $C_n$     | 28          | 0         |
| $C_i$     | 18          | 3         |
| D         | 35          | 0         |
| $I_{3-0}$ | 68          | 0         |

## II. Guaranteed Performance Over Commercial Operating Range.

$$V_{CC} = 4.75 \text{ to } 5.25V, T_A = 0 \text{ to } 70^\circ C$$

**TABLE IIA**  
Clock Characteristics.

|                         |      |
|-------------------------|------|
| Minimum Clock LOW Time  | 31ns |
| Minimum Clock HIGH Time | 33ns |

**TABLE IIB**  
Output Enable/Disable Times.

All in ns.  
 $C_L = 5.0pF$  for output disable tests.

| From      | To | Enable | Disable |
|-----------|----|--------|---------|
| $I_{3-0}$ | Y  | 80     | 55      |

**TABLE IIC**  
Combinational Propagation Delays.

All in ns.  
Outputs fully loaded.  $C_L = 50pF$ .

| To Output  | Y  | $C_{n+4}$ | $C_{i+4}$<br>(Note 1) | $C_{i+4}$<br>(Note 2) | Full |
|------------|----|-----------|-----------------------|-----------------------|------|
| From Input |    |           |                       |                       |      |
| $I_{3-0}$  | 81 | 77        | 91                    | 80                    | 69   |
| $C_n$      | 32 | 25        | 45                    | —                     | —    |
| $C_i$      | —  | —         | 22                    | 22                    | —    |
| CP         | 69 | 61        | 78                    | 43                    | 55   |
| D          | 39 | —         | 50                    | —                     | —    |

Notes: 1. Instructions 5, 7, 11, 12, 13, 14.  
2. All instructions except 5, 7, 11, 12, 13, 14.

**TABLE IID**  
Set-up and Hold Times. All in ns.

All relative to clock  
LOW-to-HIGH transition.

| Input     | CP:         |           |
|-----------|-------------|-----------|
|           | Set-up Time | Hold Time |
| $C_n$     | 43          | 0         |
| $C_i$     | 32          | 5         |
| D         | 52          | 2         |
| $I_{3-0}$ | 114         | 0         |

## III. Guaranteed Performance Over Military Operating Range.

$$V_{CC} = 4.5 \text{ to } 5.5V, T_C = -55 \text{ to } +125^\circ C$$

**TABLE IIIA**  
Clock Characteristics.

|                         |      |
|-------------------------|------|
| Minimum Clock LOW Time  | 35ns |
| Minimum Clock HIGH Time | 35ns |

**TABLE IIIB**  
Output Enable/Disable Times.

All in ns.  
 $C_L = 5.0pF$  for output disable tests.

| From      | To | Enable | Disable |
|-----------|----|--------|---------|
| $I_{3-0}$ | Y  | 85     | 60      |

**TABLE IIIC**  
Combinational Propagation Delays.

All in ns.  
Outputs fully loaded.  $C_L = 50pF$ .

| To Output  | Y  | $C_{n+4}$ | $C_{i+4}$<br>(Note 1) | $C_{i+4}$<br>(Note 2) | Full |
|------------|----|-----------|-----------------------|-----------------------|------|
| From Input |    |           |                       |                       |      |
| $I_{3-0}$  | 88 | 82        | 97                    | 87                    | 78   |
| $C_n$      | 37 | 30        | 46                    | —                     | —    |
| $C_i$      | —  | —         | 23                    | 23                    | —    |
| CP         | 74 | 66        | 84                    | 45                    | 60   |
| D          | 44 | —         | 55                    | —                     | —    |

Notes: 1. Instructions 5, 7, 11, 12, 13, 14.  
2. All instructions except 5, 7, 11, 12, 13, 14.

**TABLE IIID**  
Set-up and Hold Times. All in ns.

All relative to clock  
LOW-to-HIGH transition.

| Input     | CP:         |           |
|-----------|-------------|-----------|
|           | Set-up Time | Hold Time |
| $C_n$     | 52          | 0         |
| $C_i$     | 37          | 5         |
| D         | 60          | 2         |
| $I_{3-0}$ | 124         | 0         |

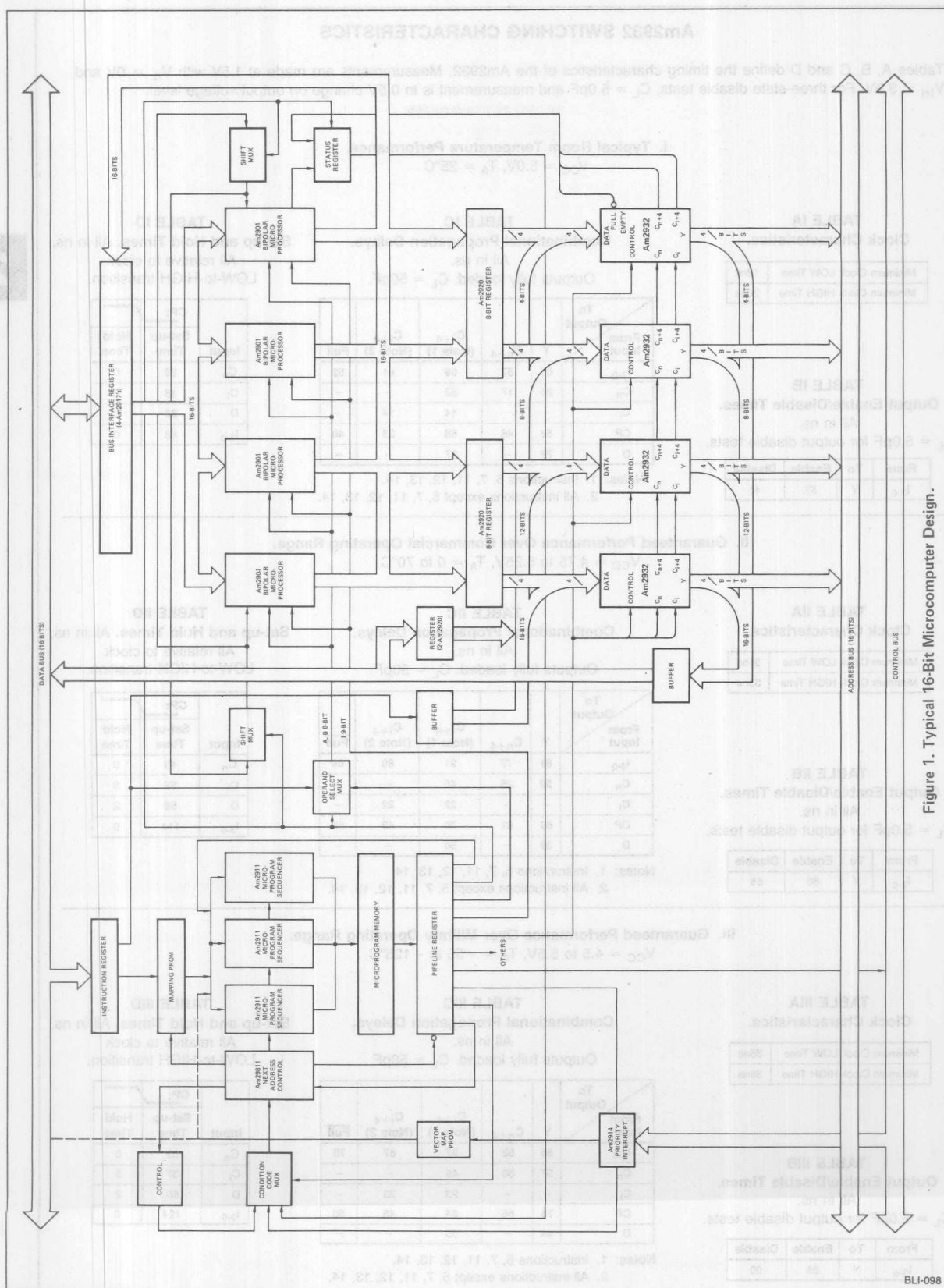


Figure 1. Typical 16-Bit Microcomputer Design.



APPLICATIONS

The Am2932 is shown in a typical 16-bit, 2900 Microcomputer design in Figure 1.

The Direct inputs (D) of the Am2932 are derived from one of three sources: the Instruction Register, the Data Bus via a 16-bit register (two Am2920 8-bit Registers), and the output of the Am2901s via a 16-bit register.

The Address outputs (Y) of the Am2932 are passed to the address bus.

The  $C_{n+4}$  output can be wired to the next higher  $C_n$  input to provide ripple block arithmetic.

The control inputs of the Am2932 ( $I_{0-3}$ ,  $C_i$  and  $C_n$  of the least significant device) are shown originating at the Pipeline Register.

PIN DEFINITIONS

- $I_{0-3}$  The four Instruction control lines to the Am2932, used to establish data paths and enable internal registers.
- $C_n$  The carry-in to the Full Adder.
- $C_{n+4}$  The carry-out of the Full Adder.
- $C_i$  The carry-in to the program counter incrementer.
- $C_{i+4}$  The carry-out of the program counter incrementer.
- $Y_{0-3}$  The four address outputs of the Am2932. These are three-state output lines. When enabled, they display the outputs of the Full Adder.
- $D_{0-3}$  The four Direct inputs which are used as inputs to the Auxiliary Register, the RAM, and the Full Adder, under instruction control.
- Full** The Full output is LOW when the LIFO stack is full — during and after the 17th push operation.
- CP** The clock input to the Am2932. All internal registers (R, SP, PC) and the RAM are updated on the LOW-to-HIGH transition of the clock input.

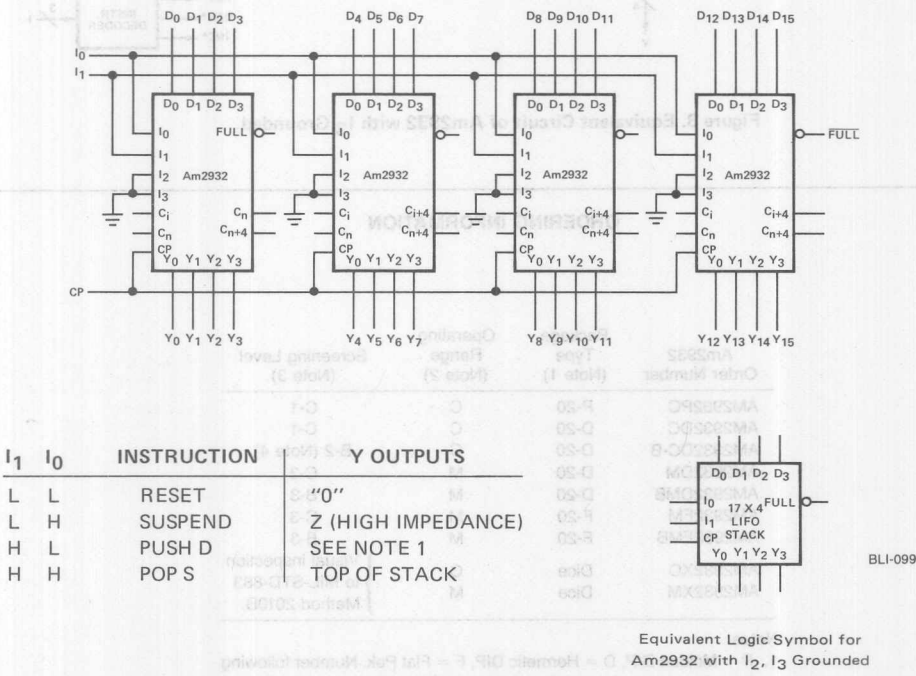


Figure shows the use of four Am2932s as a 17-word by 16-bit LIFO stack by grounding  $I_2$  and  $I_3$ . The effect of grounding  $I_3$  is shown in Figure 3.

Note 1. During this instruction, PC is placed on the Y outputs. If  $C_i$  is held LOW, the Y outputs will be LOW for this instruction after the device is initialized with a Reset instruction.

Figure 2. Application of Four Am2932s as a 17-Word by 16-Bit LIFO Stack.





# Am2940

## DMA Address Generator

### DISTINCTIVE CHARACTERISTICS

- **DMA Address Generation**  
Generates memory address, word count and DONE signal for DMA transfer operation.
- **Expandable Eight-bit Slice**  
Any number of Am2940's can be cascaded to form larger memory addresses — three devices address 16 megawords.
- **Repeat Data Transfer Capability**  
Initial memory address and word count are saved so that the data transfer can be repeated.
- **Programmable Control Modes**  
Provides four types of DMA transfer control plus memory address increment/decrement.
- **High Speed, Bipolar LSI**  
Advanced Low-Power Schottky TTL technology provides typical CLOCK to DONE propagation delay of 50ns and 24mA output current sink capability.
- **Microprogrammable**  
Executes 8 different instructions.

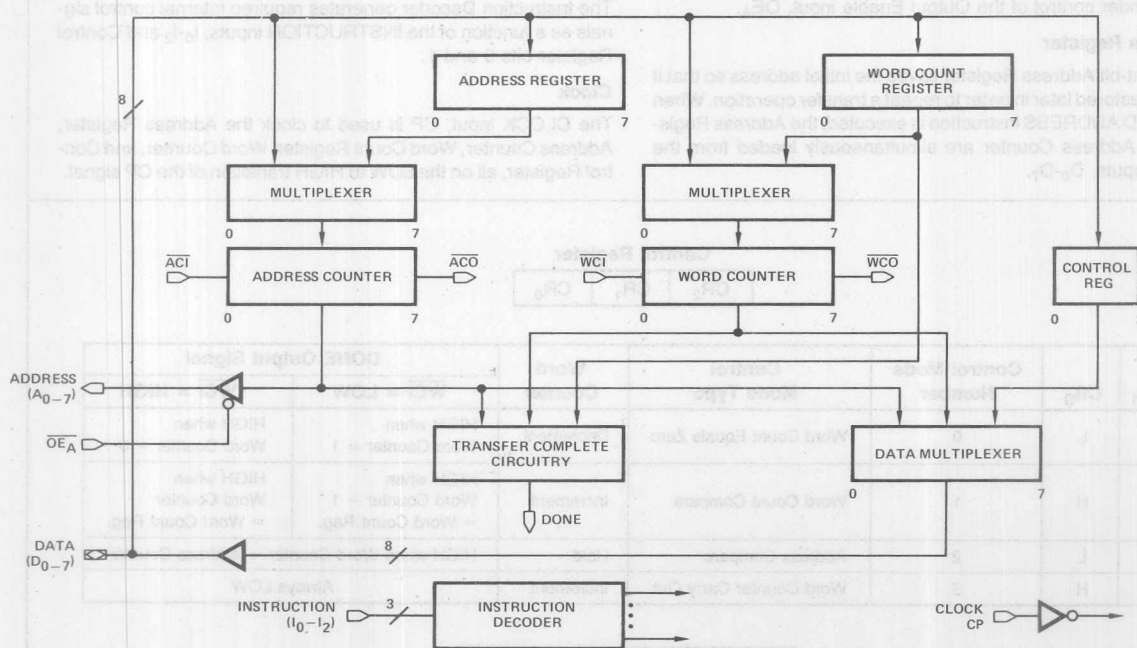
### GENERAL DESCRIPTION

The Am2940, a 28-pin member of Advanced Micro Devices Am2900 family of Low-Power Schottky bipolar LSI chips, is a high-speed, cascadable, eight-bit wide Direct Memory Access Address Generator slice. Any number of Am2940's can be cascaded to form larger addresses.

The primary function of the device is to generate sequential memory addresses for use in the sequential transfer of data to or from a memory. It also maintains a data word count and generates a DONE signal when a programmable terminal count has been reached. The device is designed for use in peripheral controllers with DMA capability or in any other system which transfers data to or from sequential locations of a memory.

The Am2940 can be programmed to increment or decrement the memory address in any of four control modes, and executes eight different instructions. The initial address and word count are saved internally by the Am2940 so that they can be restored later in order to repeat the data transfer operation.

### BLOCK DIAGRAM



Am2940 DMA Address Generator

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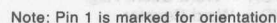


### Am2940 DMA Address Generator



## Top Views

## MPR-586





## Am2940 CONTROL MODES

## Control Mode 0 — Word Count Equals Zero Mode

In this mode, the LOAD WORD COUNT instruction loads the word count into the Word Count Register and Word Counter. When the Word Counter is enabled and the Word Counter Carry-in, WCI, is LOW, the Word Counter increments on the LOW to HIGH transition of the clock input, CP. Figure 1 specifies when the DONE signal is generated.

## Control Mode 1 — Word Count Compare Mode

In this mode the LOAD WORD COUNT instruction loads the word count into the Word Count Register and clears the Word Counter. When the Word Counter is enabled and the Word Counter Carry-in WCI, is LOW, the Word Counter increments on the LOW to HIGH transition of the clock input, CP. Figure 1 specifies when the DONE signal is generated.

## Control Mode 2 — Address Compare Mode

In this mode, only an initial and final memory address need be specified. The initial Memory Address is loaded into the Address Register and Address Counter and the final memory address is loaded into the Word Count Register and Word Counter. The Word Counter is always disabled in this mode and serves as a holding register for the final memory address. When the Address Counter is enabled and the ACI input is LOW, the Address Counter increments or decrements (depending on Control Register bit 2) on the LOW to HIGH transition of the CLOCK input, CP. The Transfer Complete Circuitry compares the Address Counter with the Word Counter and generates the DONE signal during the last word transfer, i.e. when the Address Counter equals the Word Counter.

## Control Mode 3 — Word Counter Carry Out Mode

For this mode of operation, the user can load the Word Count Register and Word Counter with the two's complement of the number of data words to be transferred. When the Word Counter is enabled and the WCI input is LOW, the Word Counter increments on the LOW to HIGH transition of the CLOCK input, CP. A Word Counter Carry Out signal, WCO, indicates the last data word is being transferred. The DONE signal is not required in this mode and, therefore, is always LOW.

## Am2940 INSTRUCTIONS

The Am2940 instruction set consists of eight instructions. Six instructions load and read the Address Counter, Word Counter and Control Register, one instruction enables the Address and Word counters, and one instruction reinitializes the Address and Word Counters. The function of the REINITIALIZE COUNTERS, LOAD WORD COUNT, and ENABLE COUNTERS instructions varies with the Control Mode being utilized. Table 1 defines the Am2940 Instructions as a function of Instruction inputs  $I_0$ - $I_2$  and the four Am2940 Control Modes.

The WRITE CONTROL REGISTER instruction writes DATA input  $D_0$ - $D_2$  into the Control Register; DATA inputs  $D_3$ - $D_7$  are "don't care" inputs for this instruction. The READ CONTROL REGISTER instruction gates the Control Register outputs to DATA lines,  $D_0$ - $D_2$ . DATA lines  $D_3$ - $D_7$  are in the HIGH state during this instruction.

The Word Counter can be read using the READ WORD COUNTER instruction, which gates the Word Counter outputs to DATA lines  $D_0$ - $D_7$ . The LOAD WORD COUNT instruction is Control Mode dependent. In Control Modes 0, 2, and 3, DATA inputs  $D_0$ - $D_7$  are written into both the Word Count Register and Word Counter. In Control Mode 1, DATA inputs  $D_0$ - $D_7$  are written into the Word Count Register and the Word Counter is cleared.

The READ ADDRESS COUNTER instruction gates the Address Counter outputs to DATA lines  $D_0$ - $D_7$ , and the LOAD ADDRESS instruction writes DATA inputs  $D_0$ - $D_7$  into both the Address Register and Address Counter.

In Control Modes 0, 1, and 3, the ENABLE COUNTERS instruction enables both the Address and Word Counters; in Control Mode 2, the Address Counter is enabled and the Word Counter holds its contents. When enabled and the carry input is active, the counters increment on the LOW to HIGH transition of the CLOCK input, CP. Thus, with this instruction applied, counting can be controlled by the carry inputs.

The REINITIALIZE COUNTERS instruction also is Control Mode dependent. In Control Modes 0, 2, and 3, the contents of the Address Register and Word Count Register are transferred to the respective Address Counter and Word Counter; in Control Mode 1, the content of the Address Register is transferred to the Address Counter and the Word Counter is cleared. The REINITIALIZE COUNTERS instruction allows a data transfer operation to be repeated without reloading the address and word count from the DATA lines.

TABLE I. Am2940 INSTRUCTIONS

| $I_2$ | $I_1$ | $I_0$ | Octal Code | Function               | Mnemonic | Control Mode | Word Reg.        | Word Counter                 | Address Reg. | Address Counter              | Control Register   | Data $D_0$ - $D_7$          |
|-------|-------|-------|------------|------------------------|----------|--------------|------------------|------------------------------|--------------|------------------------------|--------------------|-----------------------------|
| L     | L     | L     | 0          | WRITE CONTROL REGISTER | WRCR     | 0, 1, 2, 3   | HOLD             | HOLD                         | HOLD         | HOLD                         | $D_0$ - $D_2$ → CR | INPUT                       |
| L     | L     | H     | 1          | READ CONTROL REGISTER  | RDCR     | 0, 1, 2, 3   | HOLD             | HOLD                         | HOLD         | HOLD                         | HOLD               | CR → $D_0$ - $D_2$ (Note 1) |
| L     | H     | L     | 2          | READ WORD COUNTER      | RDWC     | 0, 1, 2, 3   | HOLD             | HOLD                         | HOLD         | HOLD                         | HOLD               | WC → D                      |
| L     | H     | H     | 3          | READ ADDRESS COUNTER   | RDAC     | 0, 1, 2, 3   | HOLD             | HOLD                         | HOLD         | HOLD                         | HOLD               | AC → D                      |
| H     | L     | L     | 4          | REINITIALIZE COUNTERS  | REIN     | 0, 2, 3<br>1 | HOLD<br>HOLD     | WCR → WC<br>ZERO → WC        | HOLD         | AR → AC                      | HOLD<br>HOLD       | Z<br>Z                      |
| H     | L     | H     | 5          | LOAD ADDRESS           | LDAD     | 0, 1, 2, 3   | HOLD             | HOLD                         | D → AR       | D → AC                       | HOLD               | INPUT                       |
| H     | H     | L     | 6          | LOAD WORD COUNT        | LDWC     | 0, 2, 3<br>1 | D → WR<br>D → WR | D → WC<br>ZERO → WC          | HOLD         | HOLD                         | HOLD<br>HOLD       | INPUT<br>INPUT              |
| H     | H     | H     | 7          | ENABLE COUNTERS        | ENCT     | 0, 1, 3<br>2 | HOLD<br>HOLD     | ENABLE COUNT<br>ENABLE COUNT | HOLD         | ENABLE COUNT<br>ENABLE COUNT | HOLD<br>HOLD       | Z<br>Z                      |

CR = Control Reg.  
AR = Address Reg.  
AC = Address Counter

WCR = Word Count Reg.  
WC = Word Counter  
D = Data

L = LOW  
H = HIGH  
Z = High Impedance

Note 1:  
Data Bits  $D_3$ - $D_7$  are high during this instruction.



**MAXIMUM RATINGS** (Above which the useful life may be impaired)

|   |                        |
|---|------------------------|
| Storage Temperature                                 | -65°C to +150°C        |
| Temperature (Ambient) Under Bias                    | -55°C to +125°C        |
| Supply Voltage to Ground Potential                  | -0.5V to +7.0V         |
| DC Voltage Applied to Outputs for High Output State | -0.5V to $V_{CC}$ max. |
| DC Input Voltage                                    | -0.5V to +5.5V         |
| DC Output Current, Into Outputs                     | 30mA                   |
| DC Input Current                                    | -30mA to +5.0mA        |

**OPERATING RANGE**

| P/N          | Range | Temperature                                     | $V_{CC}$   |
|--------------|-------|---|--|
| Am2940PC, DC | COM'L | $T_A = 0^\circ\text{C to } +70^\circ\text{C}$   | $V_{CC} = 5.0V \pm 5\%$ (MIN. = 4.75V MAX. = 5.25V)  |
| Am2940DM, FM | MIL   | $T_C = -55^\circ\text{ to } +125^\circ\text{C}$ | $V_{CC} = 5.0V \pm 10\%$ (MIN. = 4.50V MAX. = 5.50V) |

**DC CHARACTERISTICS OVER OPERATING RANGE**

| Parameters             | Description                           | Test Conditions (Note 1)  | Min. | Typ.<br>(Note 2) | Max.  | Units         |
|------------------------|---------------------------------------|---|------|------------------|-------|---------------|
| $V_{OH}$               | Output HIGH Voltage                   | $V_{CC} = \text{MIN.}$ ,<br>$V_{IN} = V_{IH}$ or $V_{IL}$             | 2.4  |                  |       | Volts         |
| $V_{OL}$               | Output LOW Voltage                    | $V_{CC} = \text{MIN.}$ ,<br>$V_{IN} = V_{IH}$ or $V_{IL}$<br>(Note 5) |      |                  | 0.5   | Volts         |
|                        |                                       | MIL $I_{OH} = -1.0\text{mA}$  |      |                  |       |               |
|                        |                                       | COM'L $I_{OH} = -2.6\text{mA}$  |      |                  |       |               |
|                        |                                       | WCO, ACO<br>$A_0-7, D_0-7$<br>DONE                                    |      |                  |       |               |
| $V_{IH}$               | Input HIGH Level (Note 4)             | Guaranteed Input Logical HIGH voltage for all inputs                  | 2.0  |                  |       | Volts         |
| $V_{IL}$               | Input LOW Level (Note 4)              | Guaranteed Input Logical LOW voltage for all inputs                   |      |                  | 0.8   | Volts         |
| $V_I$                  | Input Clamp Voltage                   | $V_{CC} = \text{MIN.}$ , $I_{IN} = -18\text{mA}$                      |      |                  | -1.5  | Volts         |
| $I_{IL}$               | Input LOW Current                     | $V_{CC} = \text{MAX.}$ , $V_{IN} = 0.5V$                              |      |                  | -0.15 | mA            |
|                        |                                       | $D_0-7$<br>All Others   |      |                  | -0.8  |               |
| $I_{IH}$               | Input HIGH Current                    | $V_{CC} = \text{MAX.}$ , $V_{IN} = 2.7V$                              |      |                  | 150   | $\mu\text{A}$ |
|                        |                                       | $D_0-7$<br>All Others   |      |                  | 40    |               |
| $I_{CEX}$              | Output Leakage on DONE                | $V_{CC} = \text{MAX.}$ , $V_O = 5.5V$                                 |      |                  | 250   | $\mu\text{A}$ |
| $I_I$                  | Input HIGH Current                    | $V_{CC} = \text{MAX.}$ , $V_{IN} = 5.5V$                              |      |                  | 1.0   | mA            |
| $I_{SC}$               | Output Short Circuit Current (Note 3) | $V_{CC} = \text{MAX.} + 0.5V$ , $V_O = 0.5V$                          | -30  |                  | -85   | mA            |
| $I_{OZL}$<br>$I_{OZH}$ | Output OFF Current                    | $V_{CC} = \text{MAX.}$<br>$OE = 2.4V$                                 |      |                  | -50   | $\mu\text{A}$ |
|                        |                                       | $V_{OUT} = 0.5V$  |      |                  | -150  |               |
|                        |                                       | $V_{OUT} = 2.4V$  |      |                  | 50    |               |
|                        |                                       | $A_0-7$<br>$D_0-7$  |      |                  | 150   |               |
| $I_{CC}$               | Power Supply Current                  | $V_{CC} = \text{MAX.}$  |      | 170              | 275   | mA            |
|                        |                                       | Am2940PC, DC  |      |                  | 290   |               |
|                        |                                       | $T_A = 0^\circ\text{C to } +70^\circ\text{C}$                         |      |                  | 235   |               |
|                        |                                       | $T_A = +70^\circ\text{C}$   |      |                  | 315   |               |
|                        |                                       | Am2940DM, FM  |      |                  | 225   |               |

- Notes: 1. For conditions shown as MIN. or MAX., use the appropriate value specified under Electrical Characteristics for the applicable device type.  
2. Typical limits are at  $V_{CC} = 5.0V$ ,  $25^\circ\text{C}$  ambient and maximum loading.  
3. Not more than one output should be shorted at a time. Duration of the short circuit test should not exceed one second.  
4. These input levels provide no guaranteed noise immunity and should only be tested in a static-, noise-free environment.  
5.  $I_{OL}$  limit on  $A_i$  and  $D_i$  ( $i = 0$  to  $7$ ) applies to either output individually, but not both at the same time. The sum of the loading on  $A_i$  plus  $D_i$  is limited to 24mA MIL or 32mA COM'L.

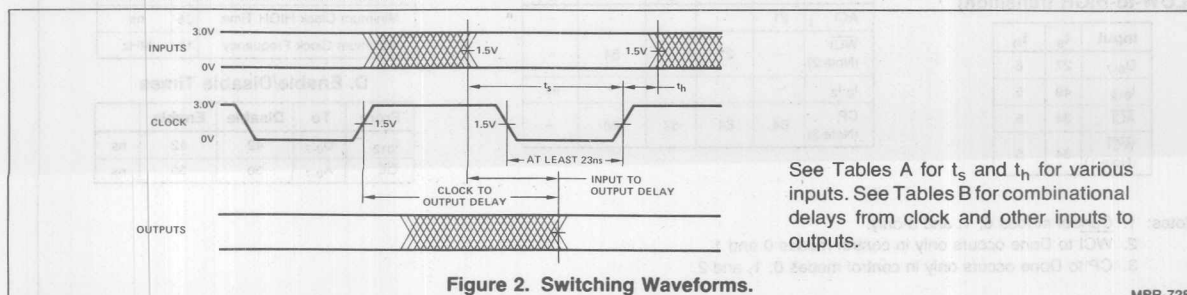


Figure 2. Switching Waveforms.

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## SWITCHING CHARACTERISTICS

The tables below define the Am2940 switching characteristics. Tables A are set-up and hold times relative to the clock LOW-to-HIGH transition. Tables B are combinational delays. Tables C are clock requirements. All measurements are made at 1.5V with input levels at 0V or 3V. All values are in ns with  $C_L = 50\text{pF}$  except output disable times (OE to A and I to D) which are specified for a 5pF load. All times are in ns.

I. TYPICAL ROOM TEMPERATURE CHARACTERISTICS ( $T_A = 25^\circ\text{C}$ ,  $V_{CC} = 5.0\text{V}$ ,  $C_L = 50\text{pF}$ )A. Set-up and Hold Times  
(Relative to clock  
LOW-to-HIGH transition)

| Input                        | $t_s$ | $t_h$ |
|------------------------------|-------|-------|
| $D_{0-7}$                    | 13    | 3     |
| $I_{012}$                    | 33    | 2     |
| $\overline{ACI}$             | 15    | 2     |
| $\overline{WCI}$<br>(Note 1) | 15    | 1     |

## B. Combinational Delays

| Input                        | $\overline{ACO}$ | $\overline{WCO}$ | $A_{0-7}$ | DONE | $D_{0-7}$ |
|------------------------------|------------------|------------------|-----------|------|-----------|
| $\overline{ACI}$             | 12               | —                | —         | —    | —         |
| $\overline{WCI}$<br>(Note 2) | —                | 12               | —         | 27   | —         |
| $I_{0-2}$                    | —                | —                | —         | —    | 21        |
| CP<br>(Note 3)               | 35               | 35               | 35        | 50   | —         |

## C. Clock Requirements

|                         |    |     |
|-------------------------|----|-----|
| Minimum Clock LOW Time  | 20 | ns  |
| Minimum Clock HIGH Time | 25 | ns  |
| Maximum Clock Frequency | 22 | MHz |

## D. Enable/Disable Times

| From            | To        | Disable | Enable |    |
|-----------------|-----------|---------|--------|----|
| $I_{012}$       | $D_{0-7}$ | 25      | 19     | ns |
| $\overline{OE}$ | $A_{0-7}$ | 19      | 13     | ns |

II. GUARANTEED ROOM TEMPERATURE CHARACTERISTICS ( $T_A = 25^\circ\text{C}$ ,  $V_{CC} = 5.0\text{V}$ ,  $C_L = 50\text{pF}$ )A. Set-up and Hold Times  
(Relative to clock  
LOW-to-HIGH transition)

| Input                        | $t_s$ | $t_h$ |
|------------------------------|-------|-------|
| $D_{0-7}$                    | 21    | 4     |
| $I_{012}$                    | 41    | 3     |
| $\overline{ACI}$             | 27    | 3     |
| $\overline{WCI}$<br>(Note 1) | 27    | 3     |

## B. Combinational Delays

| Input                        | $\overline{ACO}$ | $\overline{WCO}$ | $A_{0-7}$ | DONE | $D_{0-7}$ |
|------------------------------|------------------|------------------|-----------|------|-----------|
| $\overline{ACI}$             | 18               | —                | —         | —    | —         |
| $\overline{WCI}$<br>(Note 2) | —                | 18               | —         | 41   | —         |
| $I_{0-2}$                    | —                | —                | —         | —    | 34        |
| CP<br>(Note 3)               | 50               | 50               | 48        | 77   | —         |

## C. Clock Requirements

|                         |    |     |
|-------------------------|----|-----|
| Minimum Clock LOW Time  | 23 | ns  |
| Minimum Clock HIGH Time | 30 | ns  |
| Maximum Clock Frequency | 18 | MHz |

## D. Enable/Disable Times

| From            | To        | Disable | Enable |    |
|-----------------|-----------|---------|--------|----|
| $I_{012}$       | $D_{0-7}$ | 30      | 30     | ns |
| $\overline{OE}$ | $A_{0-7}$ | 23      | 23     | ns |

## III. GUARANTEED CHARACTERISTICS OVER COMMERCIAL OPERATING RANGE

Am2940PC, DC ( $T_A = 0^\circ\text{C}$  to  $+70^\circ\text{C}$ ,  $V_{CC} = 4.75\text{V}$  to  $5.25\text{V}$ ,  $C_L = 50\text{pF}$ )A. Set-up and Hold Times  
(Relative to clock  
LOW-to-HIGH transition)

| Input                        | $t_s$ | $t_h$ |
|------------------------------|-------|-------|
| $D_{0-7}$                    | 24    | 5     |
| $I_{012}$                    | 46    | 4     |
| $\overline{ACI}$             | 30    | 4     |
| $\overline{WCI}$<br>(Note 1) | 30    | 3     |

## B. Combinational Delays

| Input                        | $\overline{ACO}$ | $\overline{WCO}$ | $A_{0-7}$ | DONE | $D_{0-7}$ |
|------------------------------|------------------|------------------|-----------|------|-----------|
| $\overline{ACI}$             | 20               | —                | —         | —    | —         |
| $\overline{WCI}$<br>(Note 2) | —                | 20               | —         | 46   | —         |
| $I_{0-2}$                    | —                | —                | —         | —    | 37        |
| CP<br>(Note 3)               | 58               | 58               | 54        | 85   | —         |

## C. Clock Requirements

|                         |    |     |
|-------------------------|----|-----|
| Minimum Clock LOW Time  | 23 | ns  |
| Minimum Clock HIGH Time | 34 | ns  |
| Maximum Clock Frequency | 17 | MHz |

## D. Enable/Disable Times

| From            | To        | Disable | Enable |    |
|-----------------|-----------|---------|--------|----|
| $I_{012}$       | $D_{0-7}$ | 35      | 35     | ns |
| $\overline{OE}$ | $A_{0-7}$ | 25      | 25     | ns |

## IV. GUARANTEED CHARACTERISTICS OVER MILITARY OPERATING RANGE

Am2940DM, FM ( $T_C = -55^\circ\text{C}$  to  $+125^\circ\text{C}$ ,  $V_{CC} = 4.5\text{V}$  to  $5.5\text{V}$ ,  $C_L = 50\text{pF}$ )A. Set-up and Hold Times  
(Relative to clock  
LOW-to-HIGH transition)

| Input                        | $t_s$ | $t_h$ |
|------------------------------|-------|-------|
| $D_{0-7}$                    | 27    | 6     |
| $I_{012}$                    | 49    | 5     |
| $\overline{ACI}$             | 34    | 5     |
| $\overline{WCI}$<br>(Note 1) | 34    | 5     |

## B. Combinational Delays

| Input                        | $\overline{ACO}$ | $\overline{WCO}$ | $A_{0-7}$ | DONE | $D_{0-7}$ |
|------------------------------|------------------|------------------|-----------|------|-----------|
| $\overline{ACI}$             | 21               | —                | —         | —    | —         |
| $\overline{WCI}$<br>(Note 2) | —                | 21               | —         | 54   | —         |
| $I_{0-2}$                    | —                | —                | —         | —    | 41        |
| CP<br>(Note 3)               | 64               | 64               | 62        | 88   | —         |

## C. Clock Requirements

|                         |    |     |
|-------------------------|----|-----|
| Minimum Clock LOW Time  | 23 | ns  |
| Minimum Clock HIGH Time | 35 | ns  |
| Maximum Clock Frequency | 16 | MHz |

## D. Enable/Disable Times

| From            | To        | Disable | Enable |    |
|-----------------|-----------|---------|--------|----|
| $I_{012}$       | $D_{0-7}$ | 42      | 42     | ns |
| $\overline{OE}$ | $A_{0-7}$ | 30      | 30     | ns |

- Notes: 1. Control modes 0, 1, and 3 only.  
 2.  $\overline{WCI}$  to Done occurs only in control modes 0 and 1.  
 3. CP to Done occurs only in control modes 0, 1, and 2.

## APPLICATIONS

The Am2940 is designed for use in peripheral controllers with DMA capability or in any other system which transfers data to or from sequential locations of a memory. One or more Am2940's can be used in each peripheral controller of a distributed DMA system to provide the memory address and word count required for DMA operation.

Figure 3 shows a block diagram of an example microprogrammed DMA peripheral controller. The Am2910 Microprogram Sequencer, Microprogram Memory, and the Microinstruction Register form the microprogram control portion of this peripheral controller. The Am2940 generates the memory address and maintains the word count required for DMA operation. An internal three-state bus provides the communication path between the Microinstruction Register, the Am2917 Data Transceivers, the Am2940, the Am2901A Microprocessor, and the Device Interface Circuitry.

The Am2940 interconnections are shown in detail in Figure 4. Two Am2940's are cascaded to generate a sixteen-bit address. The Am2940 ADDRESS and DATA output current sink capability is 24mA over the commercial operating range. This allows the Am2940's to drive the System Address Bus and Internal Three-State Bus directly, thereby eliminating the need for separate bus drivers. Three-bits in the Microinstruction Register provide the Am2940 Instruction Inputs,  $I_0$ - $I_2$ . The microprogram clock is used to clock the Am2940's and, when the ENABLE COUNTERS instruction is applied, address and word counting is controlled by the CNT bit of the Microinstruction Register.

Asynchronous interface control circuitry generates System Bus control signals and enables the Am2940 Address onto the System Address Bus at the appropriate time. The open-collector DONE outputs are dot-and-ed and used as a test input to the Am2910 Microprogram Sequencer.

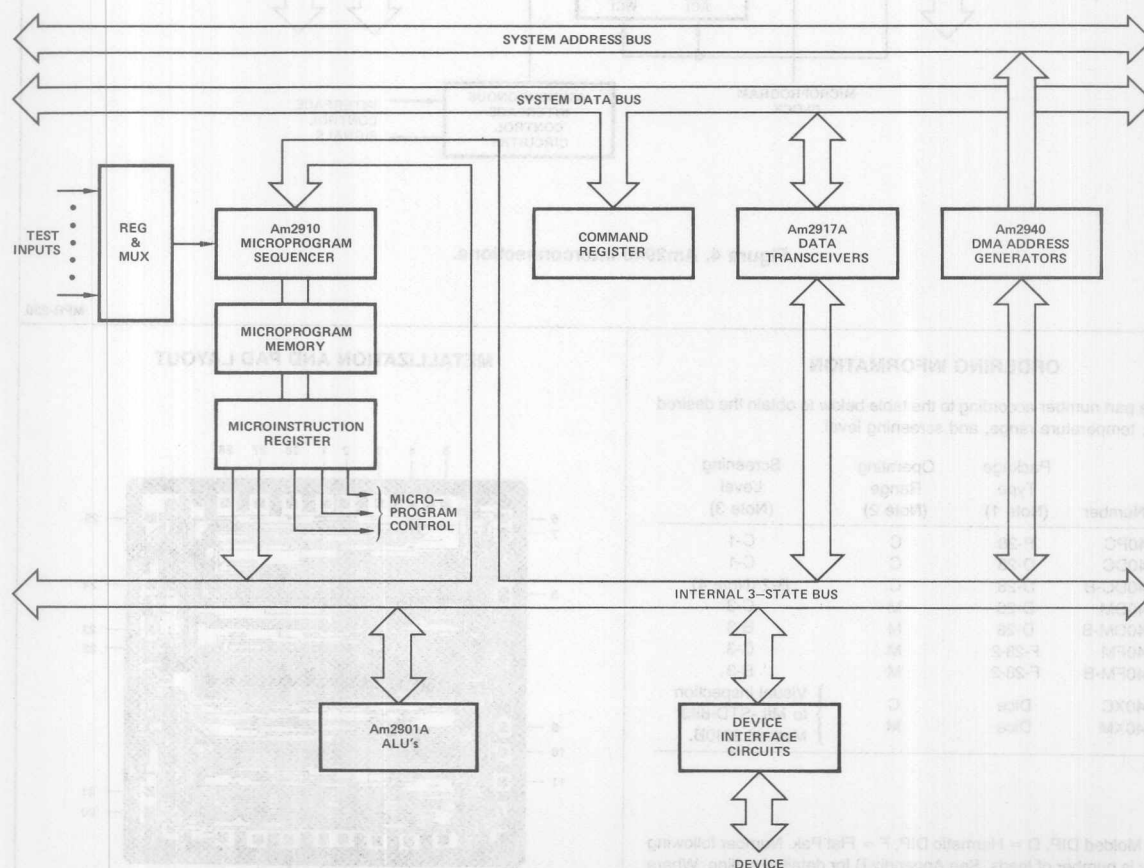


Figure 3. DMA Peripheral Controller Block Diagram.

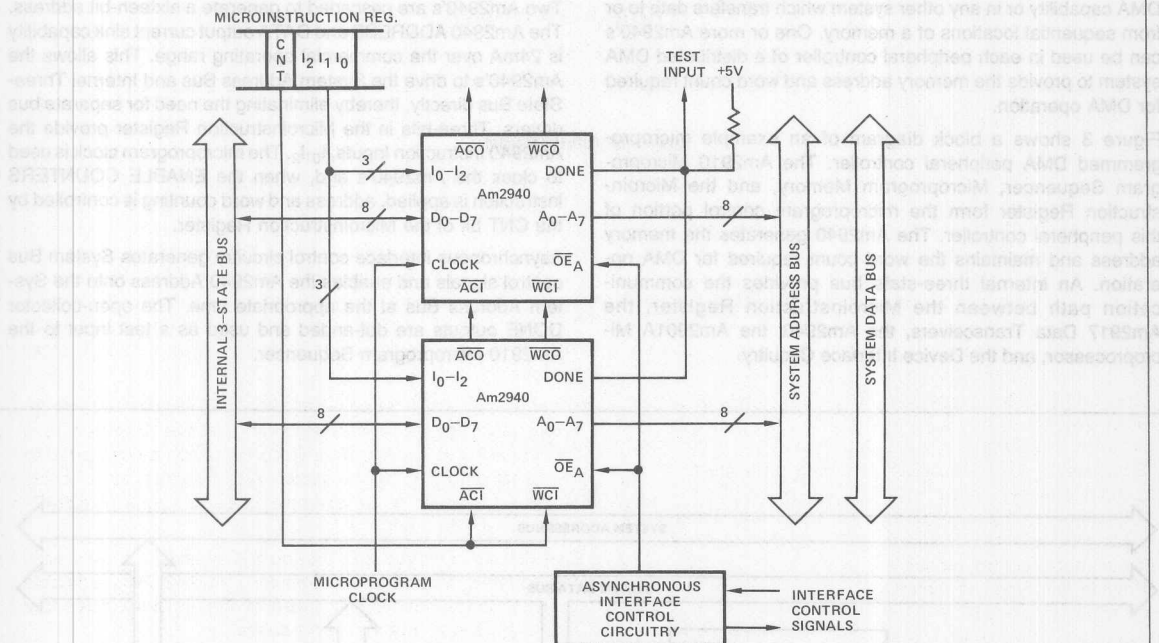


Figure 4. Am2940 Interconnections.

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### ORDERING INFORMATION

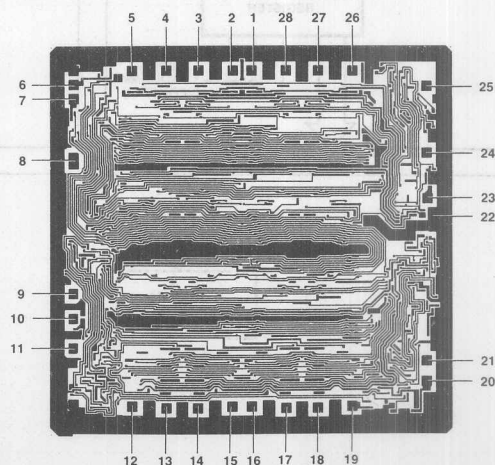
Order the part number according to the table below to obtain the desired package, temperature range, and screening level.

| Order Number | Package Type<br>(Note 1) | Operating Range<br>(Note 2) | Screening Level<br>(Note 3)                          |
|--------------|--------------------------|-----------------------------|--|
| AM2940PC     | P-28                     | C                           | C-1  |
| AM2940DC     | D-28                     | C                           | C-1  |
| AM2940DC-B   | D-28                     | C                           | B-2 (Note 4)   |
| AM2940DM     | D-28                     | M                           | C-3  |
| AM2940DM-B   | D-28                     | M                           | B-3  |
| AM2940FM     | F-28-2                   | M                           | C-3  |
| AM2940FM-B   | F-28-2                   | M                           | B-3  |
| AM2940XC     | Dice                     | C                           | Visual inspection<br>to MIL-STD-883<br>Method 2010B. |
| AM2940XM     | Dice                     | M                           |  |

#### Notes:

- P = Molded DIP, D = Hermetic DIP, F = Flat Pak. Number following letter is number of leads. See Appendix B for detailed outline. Where Appendix B contains several dash numbers, any of the variations of the package may be used unless otherwise specified.
- C = 0°C to +70°C, V<sub>CC</sub> = 4.75V to 5.25V.  
M = -55°C to +125°C, V<sub>CC</sub> = 4.50V to 5.50V.
- See Appendix A for details of screening. Levels C-1 and C-3 conform to MIL-STD-883, Class C. Level B-3 conforms to MIL-STD-883, Class B.
- 96 hour burn-in

### METALLIZATION AND PAD LAYOUT



Note: Numbers refer to DIP pin connections.  
DIE SIZE: 0.178" X 0.181"



# Am2942

## Programmable Timer/Counter DMA Address Generator

### DISTINCTIVE CHARACTERISTICS

- 22-pin version of Am2940 –  
Provides multiplexed Address and Data lines plus additional Instruction Input and Instruction Enable pins.
- Can be used as either DMA Address Generator or Programmable Timer Counter.
- Executes 16 instructions –  
Eight DMA instructions plus eight Timer/Counter instructions
- Provides two independent programmable 8-bit up/down counters in a 22-pin package –  
Counters can be cascaded to form single-chip 16-bit up/down counter.
- Reinitialize capability –  
Counters can be reinitialized from on-chip registers.
- Expandable eight-bit slice –  
Any number of Am2942s can be cascaded. Three devices provide a 48 bit counter.
- Programmable control modes –  
Provide four types of control.
- High speed bipolar LSI –  
Advanced Low-Power Schottky TTL technology provides typical count frequency of 25MHz and 24mA output current sink capability.

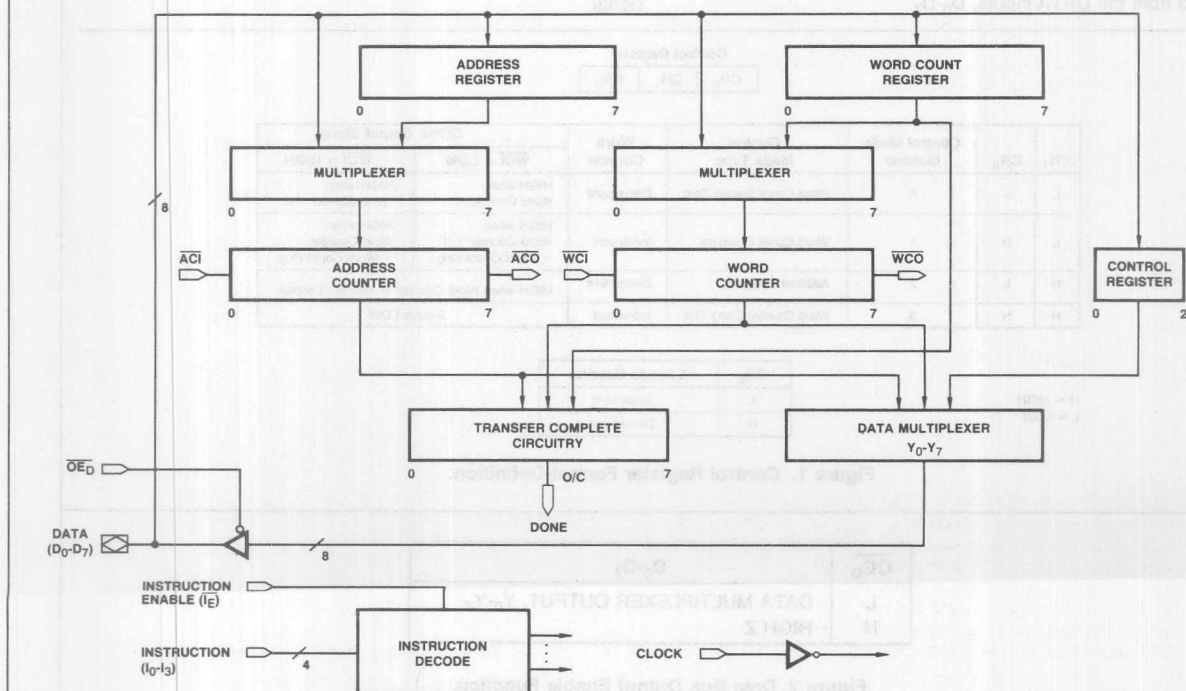
### GENERAL DESCRIPTION

The Am2942, a 22-pin version of the Am2940, can be used as a high-speed DMA Address Generator or Programmable Timer/Counter. It provides multiplexed Address and Data lines, for use with a common bus, and additional Instruction Input and Instruction Enable pins. The Am2942 executes 16 instructions; eight are the same as the Am2940 instructions, and eight instructions facilitate the use of the Am2942 as a Programmable Timer/Counter. The Instruction Enable input allows the sharing of the Am2942 instruction field with other devices.

When used as a Timer/Counter, the Am2942 provides two independent, programmable, eight-bit, up-down counters in a 22-pin package. The two on-chip counters can be cascaded to form a single chip, 16-bit counter. Also, any number of chips can be cascaded – for example three cascaded Am2942s form a 48-bit timer/counter.

Reinitialization instructions provide the capability to reinitialize the counters from on-chip registers. Am2942 Programmable Control Modes, identical to those of the Am2940, offer four different types of programmable control.

### BLOCK DIAGRAM



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**Am2942 ARCHITECTURE**

As shown in the Block Diagram, the Am2942 consists of the following:

- A three-bit Control Register.
- An eight-bit Address Counter with input multiplexer.
- An eight-bit Address Register.
- An eight-bit Word Counter with input multiplexer.
- An eight-bit Word Count Register.
- Transfer complete circuitry.
- An eight-bit wide data multiplexer with three-state output buffers.
- An instruction decoder.

**Control Register**

Under instruction control, the Control Register can be loaded or read from the bidirectional DATA lines  $D_0-D_7$ . Control Register bits 0 and 1 determine the Am2942 Control Mode, and bit 2 determines whether the Address Counter increments or decrements. Figure 1 defines the Control Register format.

**Address Counter**

The Address Counter, which provides the current memory address, is an eight-bit, binary, up/down counter with full look-ahead carry generation. The Address Carry input ( $\overline{ACI}$ ) and Address Carry Output ( $\overline{ACO}$ ) allow cascading to accommodate larger addresses. Under instruction control, the Address Counter can be enabled, disabled, and loaded from the DATA inputs,  $D_0-D_7$ , or the Address Register. When enabled and the  $\overline{ACI}$  input is LOW, the Address Counter increments/decrements on the LOW to HIGH transition of the CLOCK input, CP.

**Address Register**

The eight-bit Address Register saves the initial address so that it can be restored later in order to repeat a transfer operation. When the LOAD ADDRESS instruction is executed, the Address Register and Address Counter are simultaneously loaded from the DATA inputs,  $D_0-D_7$ .

**Word Counter and Word Count Register**

The Word Counter and Word Count Register, which maintain and save a word count, are similar in structure and operation to the Address Counter and Address Register, with the exception that the Word Counter increments in Control Modes 1 and 3, and decrements in Control Modes 0 and 2. The LOAD WORD COUNT instruction simultaneously loads the Word Counter and Word Count Register.

**Transfer Complete Circuitry**

The Transfer Complete Circuitry is a combinational logic network which detects the completion of the data transfer operation in three Control Modes and generates the DONE output signal. The DONE signal is an open-collector output, which can be dot-anded between chips.

**Data Multiplexer**

The Data Multiplexer is an eight-bit wide, three-input multiplexer which allows the Address Counter, Word Counter and Control Register to be read at DATA lines  $D_0-D_7$ . The Data Multiplexer output,  $Y_0-Y_7$ , is enabled onto DATA lines  $D_0-D_7$  if and only if the Output Enable input,  $\overline{OE_D}$ , is LOW. (Refer to Figure 2.)

**Instruction Decoder**

The Instruction Decoder generates required internal control signals as a function of the INSTRUCTION inputs,  $I_0-I_3$  Control Register bits 0 and 1, and the INSTRUCTION ENABLE input,  $\overline{I_E}$ .

**Clock**

The CLOCK input, CP is used to clock the Address Register, Address Counter, Word Count Register, Word Counter, and Control Register, all on the LOW to HIGH transition of the CP signal.

| Control Register     |        |                     |                        |              |  |
|----------------------|--------|---------------------|------------------------|--------------|--|
| $CR_2$ $CR_1$ $CR_0$ |        |                     |                        |              |  |
| $CR_1$               | $CR_0$ | Control Mode Number | Control Mode Type      | Word Counter | DONE Output Signal   |
|                      |        |                     |                        |              | $\overline{WCI} = \text{LOW}$ $\overline{WCI} = \text{HIGH}$                               |
| L                    | L      | 0                   | Word Count Equals Zero | Decrement    | HIGH when Word Counter = 1      HIGH when Word Counter = 0                                 |
| L                    | H      | 1                   | Word Count Compare     | Increment    | HIGH when Word Counter + 1 = Word Count Reg.      HIGH when Word Counter = Word Count Reg. |
| H                    | L      | 2                   | Address Compare        | Decrement    | HIGH when Word Counter = Address Counter   |
| H                    | H      | 3                   | Word Counter Carry Out | Increment    | Always LOW   |

| $CR_2$ | Address Counter |
|--------|-----------------|
| L      | Increment       |
| H      | Decrement       |

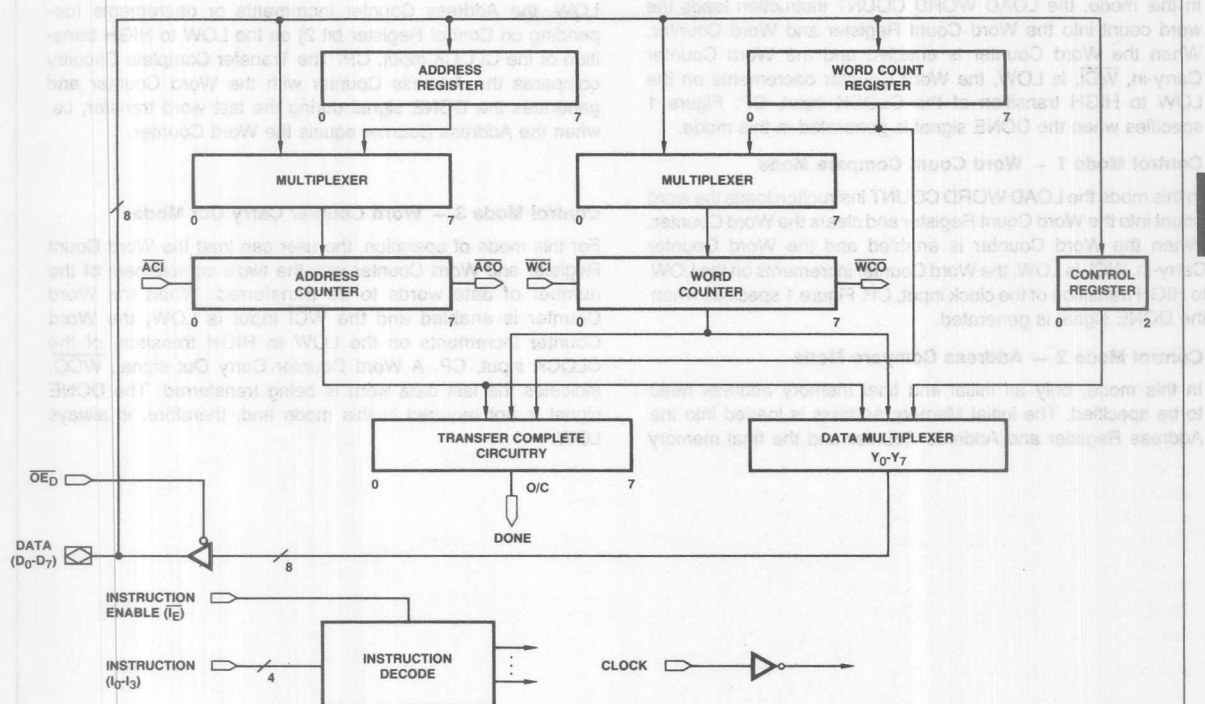
H = HIGH  
L = LOW

Figure 1. Control Register Format Definition.

| $\overline{OE_D}$ | $D_0-D_7$                          |
|-------------------|------------------------------------|
| L                 | DATA MULTIPLEXER OUTPUT, $Y_0-Y_7$ |
| H                 | HIGH Z                             |

Figure 2. Data Bus Output Enable Function.

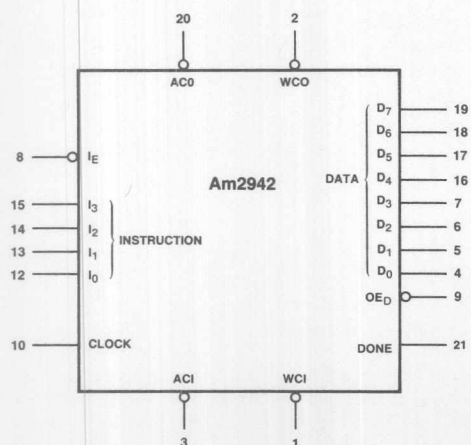
## BLOCK DIAGRAM



2

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## LOGIC SYMBOL

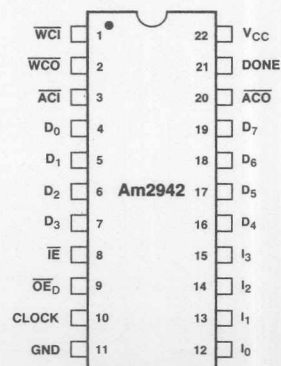


V<sub>CC</sub> = Pin 22  
GND = Pin 11

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CONNECTION DIAGRAM  
Top View

## DIP



Note: Pin 1 is marked for orientation.

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### Control Mode 0 – Word Count Equals Zero Mode

In this mode, the LOAD WORD COUNT instruction loads the word count into the Word Count Register and Word Counter. When the Word Counter is enabled and the Word Counter Carry-in,  $\overline{WCI}$ , is LOW, the Word Counter decrements on the LOW to HIGH transition of the CLOCK input, CP. Figure 1 specifies when the DONE signal is generated in this mode.

### Control Mode 1 – Word Count Compare Mode

In this mode the LOAD WORD COUNT instruction loads the word count into the Word Count Register and clears the Word Counter. When the Word Counter is enabled and the Word Counter Carry-in,  $\overline{WCI}$ , is LOW, the Word Counter increments on the LOW to HIGH transition of the clock input, CP. Figure 1 specifies when the DONE signal is generated.

### Control Mode 2 – Address Compare Mode

In this mode, only an initial and final memory address need to be specified. The initial Memory Address is loaded into the Address Register and Address Counter and the final memory

and serves as a holding register for the final memory address. When the Address Counter is enabled and the  $\overline{ACI}$  input is LOW, the Address Counter increments or decrements (depending on Control Register bit 2) on the LOW to HIGH transition of the CLOCK input, CP. The Transfer Complete Circuitry compares the Address Counter with the Word Counter and generates the DONE signal during the last word transfer, i.e. when the Address Counter equals the Word Counter.

### Control Mode 3 – Word Counter Carry Out Mode

For this mode of operation, the user can load the Word Count Register and Word Counter with the two's complement of the number of data words to be transferred. When the Word Counter is enabled and the  $\overline{WCI}$  input is LOW, the Word Counter increments on the LOW to HIGH transition of the CLOCK input, CP. A Word Counter Carry Out signal,  $\overline{WCO}$ , indicates the last data word is being transferred. The DONE signal is not required in this mode and, therefore, is always LOW.

## Am2942 INSTRUCTIONS

The Am2942 instruction set consists of sixteen instructions. Eight are DMA Instructions and are similar to the Am2940 instructions. The remaining eight instructions are designed to facilitate the use of the Am2942 as a Programmable Timer/Counter. Figures 3 and 4 define the Am2942 Instructions.

Instructions 0-7 are DMA instructions. The WRITE CONTROL REGISTER instruction writes DATA input D<sub>0</sub>-D<sub>2</sub> into the Con-

transition of the CLOCK input, CP. Thus, with this instruction applied, counting can be controlled by the carry inputs.

The REINITIALIZE COUNTERS instruction also is Control Mode dependent. In Control Modes 0, 2, and 3, the contents of the Address Register and Word Count Register are transferred to the respective Address Counter and Word Counter; in Control Mode 1, the content of the Address Register is transferred to the Address Counter and the Word Counter is

| $\overline{T}_E$ | I <sub>3</sub> | I <sub>2</sub> | I <sub>1</sub> | I <sub>0</sub> | HEX CODE |                                      |                            |
|------------------|----------------|----------------|----------------|----------------|----------|--------------------------------------|----------------------------|
| 0                | 0              | 0              | 0              | 0              | 0        | WRITE CONTROL REGISTER               | DMA INSTRUCTIONS           |
| 0                | 0              | 0              | 0              | 1              | 1        | READ CONTROL REGISTER                |                            |
| 0                | 0              | 0              | 1              | 0              | 2        | READ WORD COUNTER                    |                            |
| 0                | 0              | 0              | 1              | 1              | 3        | READ ADDRESS COUNTER                 |                            |
| 0                | 0              | 1              | 0              | 0              | 4        | REINITIALIZE COUNTERS                |                            |
| 0                | 0              | 1              | 0              | 1              | 5        | LOAD ADDRESS                         |                            |
| 0                | 0              | 1              | 1              | 0              | 6        | LOAD WORD COUNT                      |                            |
| 0                | 0              | 1              | 1              | 1              | 7        | ENABLE COUNTERS                      |                            |
| 1                | 0              | X              | X              | X              | 0-7      | INSTRUCTION DISABLE                  |                            |
| 0                | 1              | 0              | 0              | 0              | 8        | WRITE CONTROL REGISTER, T/C          | TIMER/COUNTER INSTRUCTIONS |
| 0                | 1              | 0              | 0              | 1              | 9        | REINITIALIZE ADDRESS COUNTER         |                            |
| 0                | 1              | 0              | 1              | 0              | A        | READ WORD COUNTER, T/C               |                            |
| 0                | 1              | 0              | 1              | 1              | B        | READ ADDRESS COUNTER, T/C            |                            |
| 0                | 1              | 1              | 0              | 0              | C        | REINITIALIZE ADDRESS & WORD COUNTERS |                            |
| 0                | 1              | 1              | 0              | 1              | D        | LOAD ADDRESS, T/C                    |                            |
| 0                | 1              | 1              | 1              | 0              | E        | LOAD WORD COUNT, T/C                 |                            |
| 0                | 1              | 1              | 1              | 1              | F        | REINITIALIZE WORD COUNTER            |                            |
| 1                | 1              | X              | X              | X              | 8-F      | INSTRUCTION DISABLE, T/C             |                            |

0 = LOW    1 = HIGH    X = DON'T CARE

Notes: 1. When I<sub>3</sub> is tied LOW, the Am2942 acts as a DMA circuit: When I<sub>3</sub> is tied HIGH, the Am2942 acts as a Timer/Counter circuit.

2. Am2942 instructions 0 through 7 are the same as Am2940 instructions.

Figure 3. Am2942 Instructions.

trol Register; DATA inputs D<sub>3</sub>-D<sub>7</sub> are "don't care" inputs for this instruction. The READ CONTROL REGISTER instruction gates the Control Register to Data Multiplexer outputs Y<sub>0</sub>-Y<sub>2</sub>. Outputs Y<sub>3</sub>-Y<sub>7</sub> are HIGH during this instruction.

The Word Counter can be read using the READ WORD COUNTER instruction, which gates the Word Counter to Data Multiplexer outputs, Y<sub>0</sub>-Y<sub>7</sub>. The LOAD WORD COUNT instruction is Control Mode dependent. In Control Modes 0, 2, and 3, DATA inputs D<sub>0</sub>-D<sub>7</sub> are written into both the Word Count Register and Word Counter. In Control Mode 1, DATA inputs D<sub>0</sub>-D<sub>7</sub> are written into the Word Count Register and the Word Counter is cleared.

The READ ADDRESS COUNTER instruction gates the Address Counter to Data Multiplexer outputs, Y<sub>0</sub>-Y<sub>7</sub>, and the LOAD ADDRESS instruction writes DATA inputs D<sub>0</sub>-D<sub>7</sub> into both the Address Register and Address Counter.

In Control Modes 0, 1, and 3, the ENABLE COUNTERS instruction enables both the Address and Word Counters; in Control Mode 2, the Address Counter is enabled and the Word Counter holds its contents. When enabled and the carry input is active, the counters increment on the LOW to HIGH

transition of the CLOCK input, CP. Thus, with this instruction applied, counting can be controlled by the carry inputs.

When  $\overline{T}_E$  is HIGH, Instruction inputs, I<sub>0</sub>-I<sub>2</sub>, are disabled. If I<sub>3</sub> is LOW, the function performed is identical to that of the ENABLE COUNTERS instruction. Thus, counting can be controlled by the carry inputs with the ENABLE COUNTERS instruction applied or with Instruction Inputs I<sub>0</sub>-I<sub>2</sub> disabled.

Instructions 8-F facilitate the use of the Am2942 as a Programmable Timer/Counter. They differ from instructions 0-7 in that they provide independent control of the Address Counter, Word Counter and Control Register.

The WRITE CONTROL REGISTER, T/C instruction writes DATA input D<sub>0</sub>-D<sub>2</sub> into the Control Register. DATA inputs D<sub>3</sub>-D<sub>7</sub> are "don't care" inputs for this instruction. The Address and Word Counters are enabled, and the Control Register contents appear at the Data Multiplexer output.

The REINITIALIZE ADDRESS COUNTER instruction allows the independent reinitialization of the Address Counter. The Word Counter is enabled and the contents of the Address Counter appear at the Data Multiplexer output.



The Word Counter can be read, using the READ WORD COUNTER, T/C instruction. Both counters are enabled when this instruction is executed.

When the READ ADDRESS COUNTER, T/C instruction is executed, both counters are enabled and the address counter contents appear at the Data Multiplexer output.

The REINITIALIZE ADDRESS and WORD COUNTERS instruction provides the capability to reinitialize both counters at the same time. The Address Counter contents appear at the Data Multiplexer output.

DATA inputs D<sub>0</sub>-D<sub>7</sub> are loaded into both the Address Register and Counter when the LOAD ADDRESS, T/C instruction is

executed. The Word Counter is enabled and its contents appear at the Data Multiplexer output.

The LOAD WORD COUNT, T/C instruction is identical to the LOAD WORD COUNT instruction with the exception that Address Counter is enabled.

The Word Counter can be independently reinitialized using the REINITIALIZE WORD COUNTER instruction. The Address Counter is enabled and the Word Counter contents appear at the Data Multiplexer output.

When the  $\overline{I_E}$  input is HIGH, Instruction inputs, I<sub>0</sub>-I<sub>2</sub>, are disabled. The function performed when I<sub>3</sub> is HIGH is identical to that performed when I<sub>3</sub> is LOW, with the exception that the Word Counter contents appear at the Data Multiplexer output.

| $\overline{I_E}$ | I <sub>3</sub> I <sub>2</sub> I <sub>1</sub> I <sub>0</sub><br>(Hex) | Function                               | Mnemonic | Control Mode | Word Reg. | Word Counter | Adr. Reg. | Adr. Counter | Control Reg.          | Data Multiplexer Output |
|------------------|--|--|----------|--------------|-----------|--------------|-----------|--------------|-----------------------|-------------------------|
| L                | 0  | WRITE CONTROL REGISTER                 | WRCR     | 0, 1, 2, 3   | HOLD      | HOLD         | HOLD      | HOLD         | D <sub>0-2</sub> → CR | FORCED HIGH             |
| L                | 1  | READ CONTROL REGISTER                  | RDCR     | 0, 1, 2, 3   | HOLD      | HOLD         | HOLD      | HOLD         | HOLD                  | CONTROL REG.            |
| L                | 2  | READ WORD COUNTER                      | RDWC     | 0, 1, 2, 3   | HOLD      | HOLD         | HOLD      | HOLD         | HOLD                  | WORD COUNTER            |
| L                | 3  | READ ADDRESS COUNTER                   | RDAC     | 0, 1, 2, 3   | HOLD      | HOLD         | HOLD      | HOLD         | HOLD                  | ADR. COUNTER            |
| L                | 4  | REINITIALIZE COUNTERS                  | REIN     | 0, 2, 3      | HOLD      | WR → WC      | HOLD      | AR → AC      | HOLD                  | ADR. CNTR.              |
|                  |  |  |          | 1            | HOLD      | ZERO → WC    | HOLD      | AR → AC      | HOLD                  | ADR. CNTR.              |
| L                | 5  | LOAD ADDRESS                           | LDAD     | 0, 1, 2, 3   | HOLD      | HOLD         | D → AR    | D → AC       | HOLD                  | WORD COUNTER            |
| L                | 6  | LOAD WORD COUNT                        | LDWC     | 0, 2, 3      | D → WR    | D → WC       | HOLD      | HOLD         | HOLD                  | FORCED HIGH             |
|                  |  |  |          | 1            | D → WR    | ZERO → WC    | HOLD      | HOLD         | HOLD                  | FORCED HIGH             |
| L                | 7  | ENABLE COUNTERS                        | ENCT     | 0, 1, 3      | HOLD      | ENABLE       | HOLD      | ENABLE       | HOLD                  | ADR. CNTR.              |
|                  |  |  |          | 2            | HOLD      | HOLD         | HOLD      | ENABLE       | HOLD                  | ADR. CNTR.              |
| H                | 0-7  | INSTRUCTION DISABLE                    | —        | 0, 1, 3      | HOLD      | ENABLE       | HOLD      | ENABLE       | HOLD                  | ADR. CNTR.              |
|                  |  |  |          | 2            | HOLD      | HOLD         | HOLD      | ENABLE       | HOLD                  | ADR. CNTR.              |
| L                | 8  | WRITE CONTROL REGISTER, T/C            | WCRT     | 0, 1, 2, 3   | HOLD      | ENABLE       | HOLD      | ENABLE       | D <sub>0-2</sub> → CR | CONTROL REG.            |
| L                | 9  | REINITIALIZE ADR. COUNTER              | REAC     | 0, 1, 2, 3   | HOLD      | ENABLE       | HOLD      | AR → AC      | HOLD                  | ADR. COUNTER            |
| L                | A  | READ WORD COUNTER, TC                  | RWCT     | 0, 1, 2, 3   | HOLD      | ENABLE       | HOLD      | ENABLE       | HOLD                  | WORD COUNTER            |
| L                | B  | READ ADDRESS COUNTER, T/C              | RACT     | 0, 1, 2, 3   | HOLD      | ENABLE       | HOLD      | ENABLE       | HOLD                  | ADR. COUNTER            |
| L                | C  | REINITIALIZE ADDRESS AND WORD COUNTERS | RAWC     | 0, 2, 3      | HOLD      | WR → WC      | HOLD      | AR → AC      | HOLD                  | ADR. CNTR.              |
|                  |  |  |          | 1            | HOLD      | ZERO → WC    | HOLD      | AR → AC      | HOLD                  | ADR. CNTR.              |
| L                | D  | LOAD ADDRESS, T/C                      | LDAT     | 0, 1, 2, 3   | HOLD      | ENABLE       | D → AR    | D → AC       | HOLD                  | WORD COUNTER            |
| L                | E  | LOAD WORD COUNT, T/C                   | LWCT     | 0, 2, 3      | D → WR    | D → WC       | HOLD      | ENABLE       | HOLD                  | FORCED HIGH             |
|                  |  |  |          | 1            | D → WR    | ZERO → WC    | HOLD      | ENABLE       | HOLD                  | FORCED HIGH             |
| L                | F  | REINITIALIZE WORD COUNTER              | REWC     | 0, 2, 3      | HOLD      | WR → WC      | HOLD      | ENABLE       | HOLD                  | WD. CNTR.               |
|                  |  |  |          | 1            | HOLD      | ZERO → WC    | HOLD      | ENABLE       | HOLD                  | WD. CNTR.               |
| H                | 8-F  | INSTRUCTION DISABLE, T/C               | —        | 0, 1, 3      | HOLD      | ENABLE       | HOLD      | ENABLE       | HOLD                  | WD. CNTR.               |
|                  |  |  |          | 2            | HOLD      | HOLD         | HOLD      | ENABLE       | HOLD                  | WD. CNTR.               |

WR = WORD REGISTER  
WC = WORD COUNTER  
AR = ADDRESS REGISTER

AC = ADDRESS COUNTER  
CR = CONTROL REGISTER  
D = DATA

Figure 4. Am2942 Function Table.



**MAXIMUM RATINGS** (Above which the useful life may be impaired)

|   |                        |
|---|------------------------|
| Storage Temperature                                 | -65°C to +150°C        |
| Temperature (Ambient) Under Bias                    | -55°C to +125°C        |
| Supply Voltage to Ground Potential                  | -0.5V to +7.0V         |
| DC Voltage Applied to Outputs for High Output State | -0.5V to $V_{CC}$ max. |
| DC Input Voltage                                    | -0.5V to +5.5V         |
| DC Output Current, Into Outputs                     | 30mA                   |
| DC Input Current                                    | -30mA to +5.0mA        |

**OPERATING RANGE**

| P/N          | Range | Temperature                                     | $V_{CC}$   |
|--------------|-------|---|--|
| Am2942PC, DC | COM'L | $T_A = 0^\circ\text{C to } +70^\circ\text{C}$   | $V_{CC} = 5.0V \pm 5\%$ (MIN. = 4.75V MAX. = 5.25V)  |
| Am2942DM, FM | MIL   | $T_C = -55^\circ\text{ to } +125^\circ\text{C}$ | $V_{CC} = 5.0V \pm 10\%$ (MIN. = 4.50V MAX. = 5.50V) |

2

**DC CHARACTERISTICS OVER OPERATING RANGE**

| Parameters             | Description                           | Test Conditions (Note 1)                                  | Min. | Typ.<br>(Note 2) | Max.  | Units         |
|------------------------|---------------------------------------|---|------|------------------|-------|---------------|
| $V_{OH}$               | Output HIGH Voltage                   | $V_{CC} = \text{MIN.}$ ,<br>$V_{IN} = V_{IH}$ or $V_{IL}$ | 2.4  |                  |       | Volts         |
| $V_{OL}$               | Output LOW Voltage                    | $V_{CC} = \text{MIN.}$ ,<br>$V_{IN} = V_{IH}$ or $V_{IL}$ |      |                  | 0.5   | Volts         |
|                        |                                       | WCO, ACO  |      |                  |       |               |
|                        |                                       | MIL $I_{OL} = 8.0\text{mA}$                               |      |                  |       |               |
|                        |                                       | COM'L $I_{OL} = 12\text{mA}$                              |      |                  |       |               |
| $V_{IH}$               | Input HIGH Level (Note 4)             | Guaranteed Input Logical HIGH voltage for all inputs      | 2.0  |                  |       | Volts         |
|                        |                                       |   |      |                  |       |               |
| $V_{IL}$               | Input LOW Level (Note 4)              | Guaranteed Input Logical LOW voltage for all inputs       |      |                  | 0.8   | Volts         |
| $V_I$                  | Input Clamp Voltage                   | $V_{CC} = \text{MIN.}$ , $I_{IN} = -18\text{mA}$          |      |                  | -1.5  | Volts         |
| $I_{IL}$               | Input LOW Current                     | $V_{CC} = \text{MAX.}$ , $V_{IN} = 0.5V$                  |      |                  | -0.15 | mA            |
|                        |                                       | $D_0-7$   |      |                  | -0.8  |               |
| $I_{IH}$               | Input HIGH Current                    | $V_{CC} = \text{MAX.}$ , $V_{IN} = 2.7V$                  |      |                  | 150   | $\mu\text{A}$ |
|                        |                                       | All Others  |      |                  | 40    |               |
| $I_{CEX}$              | Output Leakage on DONE                | $V_{CC} = \text{MAX.}$ , $V_O = 5.5V$                     |      |                  | 250   | $\mu\text{A}$ |
| $I_I$                  | Input HIGH Current                    | $V_{CC} = \text{MAX.}$ , $V_{IN} = 5.5V$                  |      |                  | 1.0   | mA            |
| $I_{SC}$               | Output Short Circuit Current (Note 3) | $V_{CC} = \text{MAX.}$ , $+0.5V$ , $V_O = 0.5V$           | -30  |                  | -85   | mA            |
| $I_{OZL}$<br>$I_{OZH}$ | Output OFF Current                    | $V_{CC} = \text{MAX.}$ ,<br>$OE = 2.4V$                   |      |                  | -150  | $\mu\text{A}$ |
|                        |                                       | $V_{OUT} = 0.5V$ , $D_0-7$                                |      |                  | 150   |               |
| $I_{CC}$               | Power Supply Current                  | $V_{CC} = \text{MAX.}$                                    |      | 155              | 250   | mA            |
|                        |                                       | Am2942PC, DC  |      |                  | 265   |               |
|                        |                                       | $T_A = 0^\circ\text{C to } +70^\circ\text{C}$             |      |                  | 220   |               |
|                        |                                       | $T_A = +70^\circ\text{C}$                                 |      |                  | 285   |               |
|                        |                                       | Am2942DM, FM  |      |                  | 205   |               |
|                        |                                       | $T_C = -55^\circ\text{C to } +125^\circ\text{C}$          |      |                  |       |               |

- Notes: 1. For conditions shown as MIN. or MAX., use the appropriate value specified under Electrical Characteristics for the applicable device type.  
2. Typical limits are at  $V_{CC} = 5.0V$ , 25°C ambient and maximum loading.  
3. Not more than one output should be shorted at a time. Duration of the short circuit test should not exceed one second.  
4. These input levels provide no guaranteed noise immunity and should only be tested in a static-, noise-free environment.

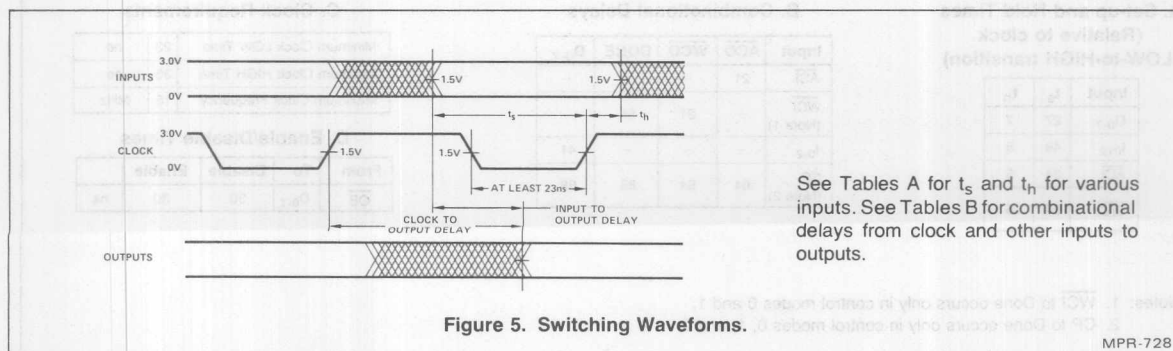


Figure 5. Switching Waveforms.

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The tables below define the Am2942 switching characteristics. Tables A are set-up and hold times relative to the clock LOW-to-HIGH transition. Tables B are combinational delays. Tables C are clock requirements. All measurements are made at 1.5V with input levels at 0V or 3V. All values are in ns with  $C_L = 50\text{pF}$  except output disable times (I to D) which are specified for a 5pF load. All times are in ns.

### I. TYPICAL ROOM TEMPERATURE CHARACTERISTICS ( $T_A = 25^\circ\text{C}$ , $V_{CC} = 5.0\text{V}$ , $C_L = 50\text{pF}$ )

#### A. Set-up and Hold Times (Relative to clock LOW-to-HIGH transition)

| Input            | $t_s$ | $t_h$ |
|------------------|-------|-------|
| $D_{0-7}$        | 13    | 3     |
| $I_{012}$        | 33    | 2     |
| $\overline{ACI}$ | 15    | 2     |
| $\overline{WCI}$ | 15    | 1     |

#### B. Combinational Delays

| Input                        | $\overline{ACO}$ | $\overline{WCO}$ | DONE | $D_{0-7}$ |
|------------------------------|------------------|------------------|------|-----------|
| $\overline{ACI}$             | 12               | —                | —    | —         |
| $\overline{WCI}$<br>(Note 1) | —                | 12               | 27   | —         |
| $I_{0-2}$                    | —                | —                | —    | 21        |
| CP<br>(Note 2)               | 35               | 35               | 50   | 37        |

#### C. Clock Requirements

|                         |    |     |
|-------------------------|----|-----|
| Minimum Clock LOW Time  | 20 | ns  |
| Minimum Clock HIGH Time | 30 | ns  |
| Maximum Clock Frequency | 28 | MHz |

#### D. Enable/Disable Times

| From            | To        | Disable | Enable |    |
|-----------------|-----------|---------|--------|----|
| $\overline{OE}$ | $D_{0-7}$ | 19      | 13     | ns |

### II. GUARANTEED ROOM TEMPERATURE CHARACTERISTICS ( $T_A = 25^\circ\text{C}$ , $V_{CC} = 5.0\text{V}$ , $C_L = 50\text{pF}$ )

#### A. Set-up and Hold Times (Relative to clock LOW-to-HIGH transition)

| Input            | $t_s$ | $t_h$ |
|------------------|-------|-------|
| $D_{0-7}$        | 21    | 4     |
| $I_{012}$        | 41    | 3     |
| $\overline{ACI}$ | 27    | 3     |
| $\overline{WCI}$ | 27    | 3     |

#### B. Combinational Delays

| Input                        | $\overline{ACO}$ | $\overline{WCO}$ | DONE | $D_{0-7}$ |
|------------------------------|------------------|------------------|------|-----------|
| $\overline{ACI}$             | 18               | —                | —    | —         |
| $\overline{WCI}$<br>(Note 1) | —                | 18               | 41   | —         |
| $I_{0-2}$                    | —                | —                | —    | 34        |
| CP<br>(Note 2)               | 50               | 50               | 77   | 53        |

#### C. Clock Requirements

|                         |    |     |
|-------------------------|----|-----|
| Minimum Clock LOW Time  | 23 | ns  |
| Minimum Clock HIGH Time | 30 | ns  |
| Maximum Clock Frequency | 22 | MHz |

#### D. Enable/Disable Times

| From            | To        | Disable | Enable |    |
|-----------------|-----------|---------|--------|----|
| $\overline{OE}$ | $D_{0-7}$ | 23      | 23     | ns |

### III. GUARANTEED CHARACTERISTICS OVER COMMERCIAL OPERATING RANGE Am2942PC, DC ( $T_A = 0^\circ\text{C}$ to $+70^\circ\text{C}$ , $V_{CC} = 4.75\text{V}$ to $5.25\text{V}$ , $C_L = 50\text{pF}$ )

#### A. Set-up and Hold Times (Relative to clock LOW-to-HIGH transition)

| Input            | $t_s$ | $t_h$ |
|------------------|-------|-------|
| $D_{0-7}$        | 24    | 6     |
| $I_{012}$        | 46    | 5     |
| $\overline{ACI}$ | 30    | 4     |
| $\overline{WCI}$ | 30    | 3     |

#### B. Combinational Delays

| Input                        | $\overline{ACO}$ | $\overline{WCO}$ | DONE | $D_{0-7}$ |
|------------------------------|------------------|------------------|------|-----------|
| $\overline{ACI}$             | 20               | —                | —    | —         |
| $\overline{WCI}$<br>(Note 1) | —                | 20               | 46   | —         |
| $I_{0-2}$                    | —                | —                | —    | 37        |
| CP<br>(Note 2)               | 58               | 58               | 85   | 59        |

#### C. Clock Requirements

|                         |    |     |
|-------------------------|----|-----|
| Minimum Clock LOW Time  | 23 | ns  |
| Minimum Clock HIGH Time | 34 | ns  |
| Maximum Clock Frequency | 20 | MHz |

#### D. Enable/Disable Times

| From            | To        | Disable | Enable |    |
|-----------------|-----------|---------|--------|----|
| $\overline{OE}$ | $D_{0-7}$ | 25      | 25     | ns |

### IV. GUARANTEED CHARACTERISTICS OVER MILITARY OPERATING RANGE Am2942DM, FM ( $T_C = -55^\circ\text{C}$ to $+125^\circ\text{C}$ , $V_{CC} = 4.5\text{V}$ to $5.5\text{V}$ , $C_L = 50\text{pF}$ )

#### A. Set-up and Hold Times (Relative to clock LOW-to-HIGH transition)

| Input            | $t_s$ | $t_h$ |
|------------------|-------|-------|
| $D_{0-7}$        | 27    | 7     |
| $I_{012}$        | 49    | 5     |
| $\overline{ACI}$ | 34    | 5     |
| $\overline{WCI}$ | 34    | 5     |

#### B. Combinational Delays

| Input                        | $\overline{ACO}$ | $\overline{WCO}$ | DONE | $D_{0-7}$ |
|------------------------------|------------------|------------------|------|-----------|
| $\overline{ACI}$             | 21               | —                | —    | —         |
| $\overline{WCI}$<br>(Note 1) | —                | 21               | 54   | —         |
| $I_{0-2}$                    | —                | —                | —    | 41        |
| CP<br>(Note 2)               | 64               | 64               | 88   | 68        |

#### C. Clock Requirements

|                         |    |     |
|-------------------------|----|-----|
| Minimum Clock LOW Time  | 23 | ns  |
| Minimum Clock HIGH Time | 35 | ns  |
| Maximum Clock Frequency | 15 | MHz |

#### D. Enable/Disable Times

| From            | To        | Disable | Enable |    |
|-----------------|-----------|---------|--------|----|
| $\overline{OE}$ | $D_{0-7}$ | 30      | 30     | ns |

Notes: 1.  $\overline{WCI}$  to Done occurs only in control modes 0 and 1.

2. CP to Done occurs only in control modes 0, 1, and 2.

## APPLICATIONS

Figure 6 shows an Am2942 used as two independent, programmable eight-bit timer/counters. In this example, an Am2910 Microprogram Sequencer provides an address to Am27S27 512 x 8 Registered PROMs. The on-chip PROM output register is used as the Microinstruction Register.

The Am2942 Instruction input,  $I_3$ , is tied HIGH to select the eight Timer/Counter instructions. The  $\overline{I_E}$ ,  $I_0$ - $I_2$ , and  $\overline{OE_D}$  inputs are provided by the microinstruction, and the  $D_0$ - $D_7$  data lines are connected to a common Data Bus. GATE WC and GATE AC are separate enable controls for the respective Word Counter and Address Counter. The DONE,  $\overline{ACO}$  and WCO

output signals indicate that a pre-programmed time or count has been reached.

Figure 7 shows an Am2942 used as a single 16-bit programmable timer/counter. In this example, the Word Counter carry-out, WCO, is connected to the Address Counter carry-in, ACI, to form a single 16-bit counter which is enabled by the GATE signal.

Figure 8 shows two Am2942s cascaded to form a 32-bit programmable timer/counter. The two Word Counters form the low order 16 bits, and the two Address Counters form the high order bits. This allows the timer/counter to be loaded and read 16 bits at a time.

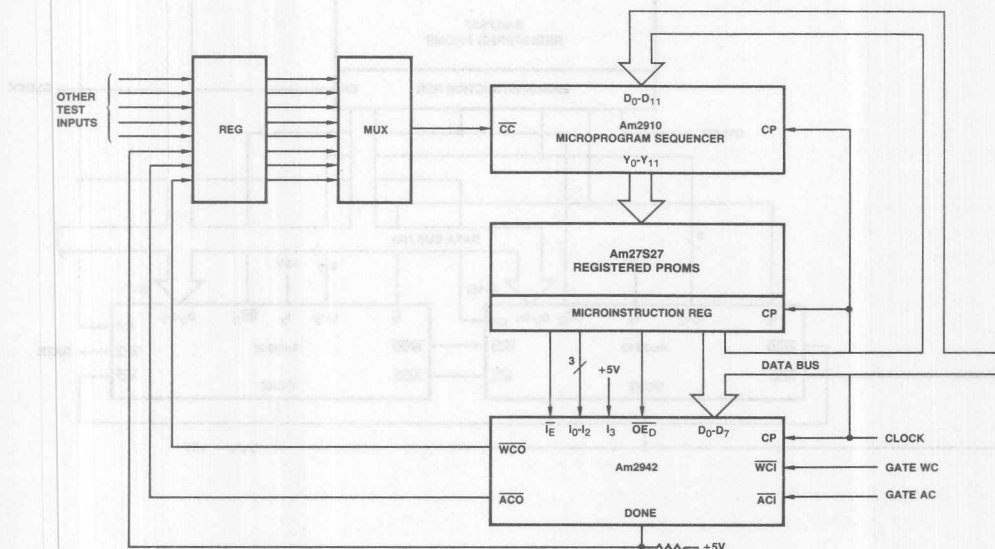


Figure 6. Two 8-Bit Programmable Counters/Timers in a 22-Pin Package.

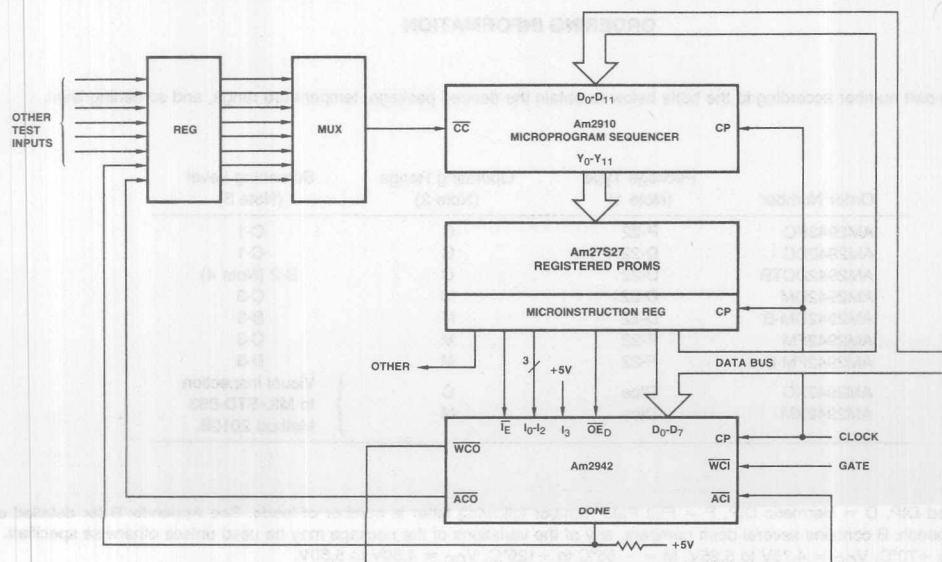


Figure 7. 16-Bit Programmable Counter/Timer Using a Single Am2942.

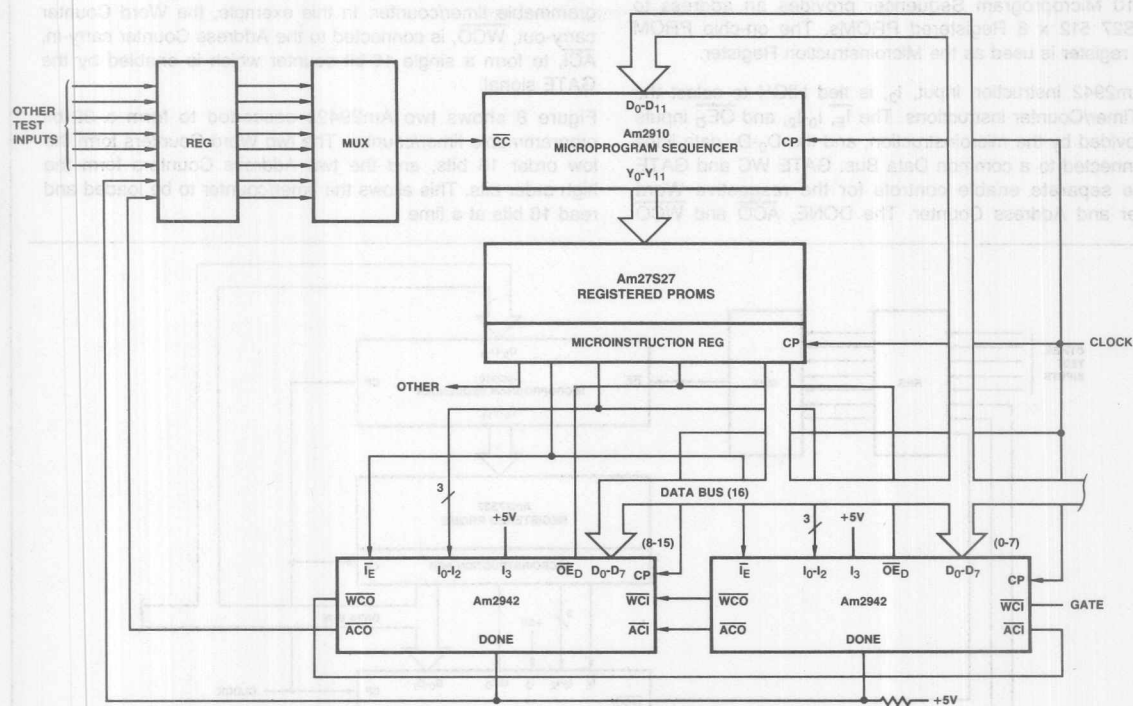


Figure 8. 32-Bit Programmable Counter/Timer Using Two Am2942s.

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## ORDERING INFORMATION

Order the part number according to the table below to obtain the desired package, temperature, and screening level.

| Order Number | Package Type<br>(Note 1) | Operating Range<br>(Note 2) | Screening Level<br>(Note 3)                          |
|--------------|--------------------------|-----------------------------|--|
| AM2942PC     | P-22                     | C                           | C-1  |
| AM2942DC     | D-22                     | C                           | C-1  |
| AM2942DCTB   | D-22                     | C                           | B-2 (Note 4)   |
| AM2942DM     | D-22                     | M                           | C-3  |
| AM2942DM-B   | D-22                     | M                           | B-3  |
| AM2942FM     | F-22                     | M                           | C-3  |
| AM2942FM-B   | F-22                     | M                           | B-3  |
| AM2942XC     | Dice                     | C                           | Visual inspection<br>to MIL-STD-883<br>Method 2010B. |
| AM2942XM     | Dice                     | M                           |  |

Notes: 1. P = Molded DIP, D = Hermetic DIP, F = Flat Pak. Number following letter is number of leads. See Appendix B for detailed outline.

Where Appendix B contains several dash numbers, any of the variations of the package may be used unless otherwise specified.

2. C = 0°C to +70°C, V<sub>CC</sub> = 4.75V to 5.25V, M = -55°C to +125°C, V<sub>CC</sub> = 4.50V to 5.50V.

3. See Appendix A for details of screening. Levels C-1 and C-3 conform to MIL-STD-883, Class C. Level B-3 conforms to MIL-STD-883, Class B.

4. 96 hour burn-in.

# Am2946 • Am2947

## Octal 3-State Bidirectional Bus Transceivers

### DISTINCTIVE CHARACTERISTICS

- 8-bit bidirectional data flow reduces system package count
- 3-state inputs/outputs for interfacing with bus-oriented systems
- PNP inputs reduce input loading
- $V_{CC} - 1.15V$   $V_{OH}$  interfaces with TTL, MOS and CMOS
- 48mA, 300pF bus drive capability
- Am2946 has inverting transceivers
- Am2947 has non-inverting transceivers
- Transmit/Receive and Chip Disable simplify control logic
- 20-pin ceramic and molded DIP package
- Low power – 8mA per bidirectional bit
- Advanced Schottky processing
- Bus port stays in hi-impedance state during power up/down
- 100% product assurance screening to MIL-STD-883 requirements

### FUNCTIONAL DESCRIPTION

The Am2946 and Am2947 are 8-bit 3-state Schottky transceivers. They provide bidirectional drive for bus-oriented microprocessor and digital communications systems. Straight through bidirectional transceivers are featured, with 24mA drive capability on the A ports and 48mA bus drive capability on the B ports. PNP inputs are incorporated to reduce input loading.

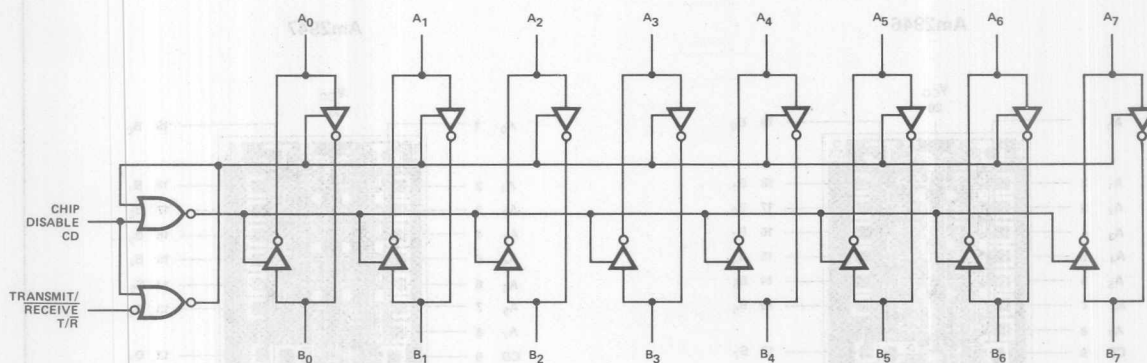
One input, Transmit/Receive determines the direction of logic signals through the bidirectional transceiver. The Chip Disable input disables both A and B ports by placing them in a 3-state condition. Chip Disable is functionally the same as an active LOW chip select.

The output high voltage ( $V_{OH}$ ) is specified at  $V_{CC} - 1.15V$  minimum to allow interfacing with MOS, CMOS, TTL, ROM, RAM or microprocessors.

2

### LOGIC DIAGRAM

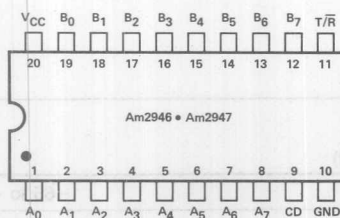
Am2946



Am2947 has non-inverting transceivers.

BLI-101

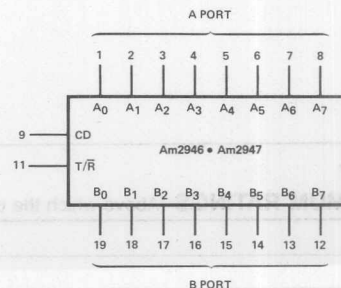
### CONNECTION DIAGRAM Top View



Note: Pin 1 is marked for orientation.

BLI-102

### LOGIC SYMBOL



$V_{CC}$  = Pin 20  
GND = Pin 10

BLI-103



ORDERING INFORMATION

Order the part number according to the table below to obtain the desired package, temperature range, and screening level.

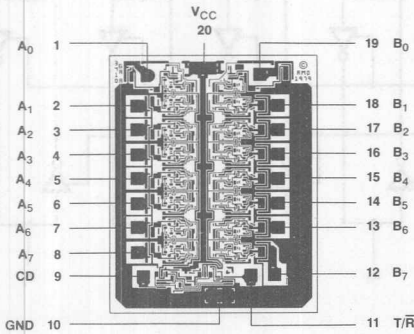
| Am2946<br>Order Number | Am2947<br>Order Number | Package Type<br>(Note 1) | Operating<br>(Note 2) | Screening Level<br>(Note 3)                          |
|------------------------|------------------------|--------------------------|-----------------------|--|
| AM2946PC               | AM2947PC               | P-20-1                   | C                     | C-1  |
| AM2946DC               | AM2947DC               | D-20-1                   | C                     | C-1  |
| AM2946DC-B             | AM2947DC-B             | D-20-1                   | C                     | B-1  |
| AM2946DM               | AM2947DM               | D-20-1                   | M                     | C-3  |
| AM2946DM-B             | AM2947DM-B             | D-20-1                   | M                     | B-3  |
| AM2946XC               | AM2947XC               | Dice                     | C                     | Visual inspection<br>to MIL-STD-883<br>Method 2010B. |

Notes:

1. P = Molded DIP, D = Hermetic DIP, F = Flat Pak. Number following letter is number of leads. See Appendix B for detailed outline. Where Appendix B contains several dash numbers, any of the variations of the package may be used unless otherwise specified.
2. C = 0 to 70°C,  $V_{CC} = 4.75V$  to 5.25V, M = -55 to + 125°C,  $V_{CC} = 4.50V$  to 5.50V.
3. See Appendix A for details of screening. Levels C-1 and C-3 conform to MIL-STD-883, Class C. Level B-3 conforms to MIL-STD-883, Class B.
4. 96 hour burn-in.

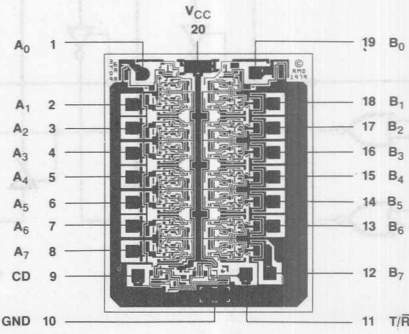
Metallization and Pad Layouts

Am2946



DIE SIZE 0.069" X 0.089"

Am2947



DIE SIZE 0.069" X 0.089"

Am2946 • Am2947

ABSOLUTE MAXIMUM RATINGS (Above which the useful life may be impaired)

|  |               |
|--|---------------|
| Storage Temperature                      | -65 to +150°C |
| Supply Voltage                           | 7.0V          |
| Input Voltage                            | 5.5V          |
| Output Voltage                           | 5.5V          |
| Lead Temperature (Soldering, 10 seconds) | 300°C         |

**ELECTRICAL CHARACTERISTICS**

The Following Conditions Apply Unless Otherwise Noted:

|       |                                     |                                   |                                   |
|-------|-------------------------------------|-----------------------------------|-----------------------------------|
| MIL   | $T_A = -55$ to $+125^\circ\text{C}$ | $V_{CC\text{MIN}} = 4.5\text{V}$  | $V_{CC\text{MAX}} = 5.5\text{V}$  |
| COM'L | $T_A = 0$ to $70^\circ\text{C}$     | $V_{CC\text{MIN}} = 4.75\text{V}$ | $V_{CC\text{MAX}} = 5.25\text{V}$ |

**DC ELECTRICAL CHARACTERISTICS** over operating temperature range

| Parameters                               | Description                            | Test Conditions   | Min   | Typ<br>(Note 1)                     | Max                                | Units   |    |
|--|--|---|---|-------------------------------------|------------------------------------|---------|----|
| A PORT (A <sub>0</sub> -A <sub>7</sub> ) |  |   |   |                                     |                                    |         |    |
| V <sub>IH</sub>                          | Logical "1" Input Voltage              | CD = V <sub>IL</sub> MAX, T/ $\overline{R}$ = 2.0V  | 2.0   |                                     |                                    | Volts   |    |
| V <sub>IL</sub>                          | Logical "0" Input Voltage              | CD = V <sub>IL</sub> MAX,<br>T/ $\overline{R}$ = 2.0V   | COM'L<br>MIL  |                                     | 0.8<br>0.7                         | Volts   |    |
| V <sub>OH</sub>                          | Logical "1" Output Voltage             | CD = V <sub>IL</sub> MAX,<br>T/ $\overline{R}$ = 0.8 V  | I <sub>OH</sub> = -0.4mA<br>I <sub>OH</sub> = -3.0mA                          | V <sub>CC</sub> -1.15<br>2.7        | V <sub>CC</sub> -0.7<br>3.95       | Volts   |    |
| V <sub>OL</sub>                          | Logical "0" Output Voltage             | CD = V <sub>IL</sub> MAX,<br>T/ $\overline{R}$ = 0.8 V  | I <sub>OL</sub> = 12mA<br>COM'L, I <sub>OL</sub> = 24mA                       |                                     | 0.3<br>0.35<br>0.4<br>0.50         | Volts   |    |
| I <sub>OS</sub>                          | Output Short Circuit Current           | CD = V <sub>IL</sub> MAX, T/ $\overline{R}$ = 0.8V, V <sub>O</sub> = 0V,<br>V <sub>CC</sub> = MAX, Note 2 | -10   | -38                                 | -75                                | mA      |    |
| I <sub>IH</sub>                          | Logical "1" Input Current              | CD = V <sub>IL</sub> MAX, T/ $\overline{R}$ = 2.0V, V <sub>I</sub> = 2.7V                                 |   | 0.1                                 | 80                                 | $\mu$ A |    |
| I <sub>I</sub>                           | Input Current at Maximum Input Voltage | CD = 2.0V, V <sub>CC</sub> = MAX, V <sub>I</sub> = V <sub>CC</sub> MAX                                    |   |                                     | 1                                  | mA      |    |
| I <sub>IL</sub>                          | Logical "0" Input Current              | CD = V <sub>IL</sub> MAX, T/ $\overline{R}$ = 2.0V, V <sub>I</sub> = 0.4V                                 |   | -70                                 | -200                               | $\mu$ A |    |
| V <sub>C</sub>                           | Input Clamp Voltage                    | CD = 2.0V, I <sub>IN</sub> = -12mA  |   | -0.7                                | -1.5                               | Volts   |    |
| I <sub>OD</sub>                          | Output/Input 3-State Current           | CD = 2.0V   | V <sub>O</sub> = 0.4V<br>V <sub>O</sub> = 4.0V                                |                                     | -200<br>80                         | $\mu$ A |    |
| B PORT (B <sub>0</sub> -B <sub>7</sub> ) |  |   |   |                                     |                                    |         |    |
| V <sub>IH</sub>                          | Logical "1" Input Voltage              | CD = V <sub>IL</sub> MAX, T/ $\overline{R}$ = V <sub>IL</sub> MAX   | 2.0   |                                     |                                    | Volts   |    |
| V <sub>IL</sub>                          | Logical "0" Input Voltage              | CD = V <sub>IL</sub> MAX,<br>T/ $\overline{R}$ = V <sub>IL</sub> MAX                                      | COM'L<br>MIL  |                                     | 0.8<br>0.7                         | Volts   |    |
| V <sub>OH</sub>                          | Logical "1" Output Voltage             | CD = V <sub>IL</sub> MAX,<br>T/ $\overline{R}$ = 2.0V   | I <sub>OH</sub> = -0.4mA<br>I <sub>OH</sub> = -5mA<br>I <sub>OH</sub> = -10mA | V <sub>CC</sub> -1.15<br>2.7<br>2.4 | V <sub>CC</sub> -0.8<br>3.9<br>3.6 | Volts   |    |
| V <sub>OL</sub>                          | Logical "0" Output Voltage             | CD = V <sub>IL</sub> MAX,<br>T/ $\overline{R}$ = 2.0V   | I <sub>OL</sub> = 20mA<br>I <sub>OL</sub> = 48mA                              |                                     | 0.3<br>0.4<br>0.4<br>0.5           | Volts   |    |
| I <sub>OS</sub>                          | Output Short Circuit Current           | CD = V <sub>IL</sub> MAX, T/ $\overline{R}$ = 2.0V, V <sub>O</sub> = 0V,<br>V <sub>CC</sub> = MAX, Note 2 | -25   | -50                                 | -150                               | mA      |    |
| I <sub>IH</sub>                          | Logical "1" Input Current              | CD = V <sub>IL</sub> MAX, T/ $\overline{R}$ = V <sub>IL</sub> MAX, V <sub>I</sub> = 2.7V                  |   | 0.1                                 | 80                                 | $\mu$ A |    |
| I <sub>I</sub>                           | Input Current at Maximum Input Voltage | CD = 2.0V, V <sub>CC</sub> = MAX, V <sub>I</sub> = V <sub>CC</sub> MAX                                    |   |                                     | 1                                  | mA      |    |
| I <sub>IL</sub>                          | Logical "0" Input Current              | CD = V <sub>IL</sub> MAX, T/ $\overline{R}$ = V <sub>IL</sub> MAX, V <sub>I</sub> = 0.4V                  |   | -70                                 | -200                               | $\mu$ A |    |
| V <sub>C</sub>                           | Input Clamp Voltage                    | CD = 2.0V, I <sub>IN</sub> = -12mA  |   | -0.7                                | -1.5                               | Volts   |    |
| I <sub>OD</sub>                          | Output/Input 3-State Current           | CD = 2.0V   | V <sub>O</sub> = 0.4V<br>V <sub>O</sub> = 4.0V                                |                                     | -200<br>200                        | $\mu$ A |    |
| CONTROL INPUTS CD, T/ $\overline{R}$     |  |   |   |                                     |                                    |         |    |
| V <sub>IH</sub>                          | Logical "1" Input Voltage              |   | 2.0   |                                     |                                    | Volts   |    |
| V <sub>IL</sub>                          | Logical "0" Input Voltage              | COM'L<br>MIL  |   |                                     | 0.8<br>0.7                         | Volts   |    |
| I <sub>IH</sub>                          | Logical "1" Input Current              | V <sub>I</sub> = 2.7V   |   | 0.5                                 | 20                                 | $\mu$ A |    |
| I <sub>I</sub>                           | Input Current at Maximum Input Voltage | V <sub>CC</sub> = MAX, V <sub>I</sub> = V <sub>CC</sub> MAX   |   |                                     | 1.0                                | mA      |    |
| I <sub>IL</sub>                          | Logical "0" Input Current              | V <sub>I</sub> = 0.4V   | T/ $\overline{R}$<br>CD   | -0.1<br>-0.1                        | -0.25<br>-0.25                     | mA      |    |
| V <sub>C</sub>                           | Input Clamp Voltage                    | I <sub>IN</sub> = -12mA   |   | -0.8                                | -1.5                               | Volts   |    |
| POWER SUPPLY CURRENT                     |  |   |   |                                     |                                    |         |    |
| I <sub>CC</sub>                          | Power Supply Current                   | Am2946  | CD = V <sub>I</sub> = 2.0V, V <sub>CC</sub> = MAX                             |                                     | 70                                 | 100     | mA |
|  |  |   | CD = 0.4V, V <sub>INA</sub> = T/ $\overline{R}$ = 2V, V <sub>CC</sub> = MAX   |                                     | 100                                | 150     |    |
|  |  | Am2947  | CD = 2.0V, V <sub>I</sub> = 0.4V, V <sub>CC</sub> = MAX                       |                                     | 70                                 | 100     |    |
|  |  |   | CD = V <sub>INA</sub> = 0.4V, T/ $\overline{R}$ = 2V, V <sub>CC</sub> = MAX   |                                     | 90                                 | 140     |    |

Am2946 • Am2947

Am2946

AC ELECTRICAL CHARACTERISTICS ( $V_{CC} = 5.0V$ ,  $T_A = 25^\circ C$ )

| Parameters                                  | Description  | Test Conditions  | Min | Typ<br>(Note 1) | Max      | Units |
|---|--|--|-----|-----------------|----------|-------|
| <b>A PORT DATA/MODE SPECIFICATIONS</b>      |  |  |     |                 |          |       |
| $t_{PDHLA}$                                 | Propagation Delay to a Logical "0" from B Port to A Port                             | $CD = 0.4V$ , $T/\bar{R} = 0.4V$ (Figure 1)<br>$R_1 = 1k$ , $R_2 = 5k$ , $C_1 = 30pF$  |     | 8               | 12       | ns    |
| $t_{PDLHA}$                                 | Propagation Delay to a Logical "1" from B Port to A Port                             | $CD = 0.4V$ , $T/\bar{R} = 0.4V$ (Figure 1)<br>$R_1 = 1k$ , $R_2 = 5k$ , $C_1 = 30pF$  |     | 11              | 16       | ns    |
| $t_{PLZA}$                                  | Propagation Delay from a Logical "0" to 3-State from CD to A Port                    | $B_0$ to $B_7 = 2.4V$ , $T/\bar{R} = 0.4V$ (Figure 3)<br>$S_3 = 1$ , $R_5 = 1k$ , $C_4 = 15pF$   |     | 10              | 15       | ns    |
| $t_{PHZA}$                                  | Propagation Delay from a Logical "1" to 3-State from CD to A Port                    | $B_0$ to $B_7 = 0.4V$ , $T/\bar{R} = 0.4V$ (Figure 3)<br>$S_3 = 0$ , $R_5 = 1k$ , $C_4 = 15pF$   |     | 8               | 15       | ns    |
| $t_{PZLA}$                                  | Propagation Delay from 3-State to a Logical "0" from CD to A Port                    | $B_0$ to $B_7 = 2.4V$ , $T/\bar{R} = 0.4V$ (Figure 3)<br>$S_3 = 1$ , $R_5 = 1k$ , $C_4 = 30pF$   |     | 20              | 30       | ns    |
| $t_{PZHA}$                                  | Propagation Delay from 3-State to a Logical "1" from CD to A Port                    | $B_0$ to $B_7 = 0.4V$ , $T/\bar{R} = 0.4V$ (Figure 3)<br>$S_3 = 0$ , $R_5 = 5k$ , $C_4 = 30pF$   |     | 19              | 30       | ns    |
| <b>B PORT DATA/MODE SPECIFICATIONS</b>      |  |  |     |                 |          |       |
| $t_{PDHLB}$                                 | Propagation Delay to a Logical "0" from A Port to B Port                             | $CD = 0.4V$ , $T/\bar{R} = 2.4V$ (Figure 1)<br>$R_1 = 100\Omega$ , $R_2 = 1k$ , $C_1 = 300pF$<br>$R_1 = 667\Omega$ , $R_2 = 5k$ , $C_1 = 45pF$         |     | 12<br>7         | 18<br>12 | ns    |
| $t_{PDLHB}$                                 | Propagation Delay to a Logical "1" from A Port to B Port                             | $CD = 0.4V$ , $T/\bar{R} = 2.4V$ (Figure 1)<br>$R_1 = 100\Omega$ , $R_2 = 1k$ , $C_1 = 300pF$<br>$R_1 = 667\Omega$ , $R_2 = 5k$ , $C_1 = 45pF$         |     | 15<br>9         | 20<br>14 | ns    |
| $t_{PLZB}$                                  | Propagation Delay from a Logical "0" to 3-State from CD to B Port                    | $A_0$ to $A_7 = 2.4V$ , $T/\bar{R} = 2.4V$ (Figure 3)<br>$S_3 = 1$ , $R_5 = 1k$ , $C_4 = 15pF$   |     | 13              | 18       | ns    |
| $t_{PHZB}$                                  | Propagation Delay from A Logical "1" to 3-State from CD to B Port                    | $A_0$ to $A_7 = 0.4V$ , $T/\bar{R} = 2.4V$ (Figure 3)<br>$S_3 = 0$ , $R_5 = 1k$ , $C_4 = 15pF$   |     | 8               | 15       | ns    |
| $t_{PZLB}$                                  | Propagation Delay from 3-State to a Logical "0" from CD to B Port                    | $A_0$ to $A_7 = 2.4V$ , $T/\bar{R} = 2.4V$ (Figure 3)<br>$S_3 = 1$ , $R_5 = 100\Omega$ , $C_4 = 300pF$<br>$S_3 = 1$ , $R_5 = 667\Omega$ , $C_4 = 45pF$ |     | 25<br>16        | 35<br>25 | ns    |
| $t_{PZHB}$                                  | Propagation Delay from 3-State to a Logical "1" from CD to B Port                    | $A_0$ to $A_7 = 0.4V$ , $T/\bar{R} = 2.4V$ (Figure 3)<br>$S_3 = 0$ , $R_5 = 1k$ , $C_4 = 300pF$<br>$S_3 = 0$ , $R_5 = 5k\Omega$ , $C_4 = 45pF$         |     | 22<br>14        | 35<br>25 | ns    |
| <b>TRANSMIT/RECEIVE MODE SPECIFICATIONS</b> |  |  |     |                 |          |       |
| $t_{TRL}$                                   | Propagation Delay from Transmit Mode to Receive a Logical "0," $T/\bar{R}$ to A Port | $CD = 0.4V$ (Figure 2)<br>$S_1 = 1$ , $R_4 = 100\Omega$ , $C_3 = 5pF$<br>$S_2 = 1$ , $R_3 = 1k$ , $C_2 = 30pF$   |     | 23              | 35       | ns    |
| $t_{TRH}$                                   | Propagation Delay from Transmit Mode to Receive a Logical "1," $T/\bar{R}$ to A Port | $CD = 0.4V$ (Figure 2)<br>$S_1 = 0$ , $R_4 = 100\Omega$ , $C_3 = 5pF$<br>$S_2 = 0$ , $R_3 = 5k$ , $C_2 = 30pF$   |     | 22              | 35       | ns    |
| $t_{RTL}$                                   | Propagation Delay from Receive Mode to Transmit a Logical "0," $T/\bar{R}$ to B Port | $CD = 0.4V$ (Figure 2)<br>$S_1 = 1$ , $R_4 = 100\Omega$ , $C_3 = 300pF$<br>$S_2 = 1$ , $R_3 = 300\Omega$ , $C_2 = 5pF$                                 |     | 26              | 35       | ns    |
| $t_{RTH}$                                   | Propagation Delay from Receive Mode to Transmit a Logical "1," $T/\bar{R}$ to B Port | $CD = 0.4V$ (Figure 2)<br>$S_1 = 0$ , $R_4 = 1k$ , $C_3 = 300pF$<br>$S_2 = 0$ , $R_3 = 300\Omega$ , $C_2 = 5pF$  |     | 27              | 35       | ns    |

Notes: 1. All typical values given are for  $V_{CC} = 5.0V$  and  $T_A = 25^\circ C$ .

2. Only one output at a time should be shorted.

## FUNCTIONAL TABLE

| Inputs           | Conditions |     |      |
|------------------|------------|-----|------|
| Chip Disable     | 0          | 0   | 1    |
| Transmit/Receive | 0          | 1   | X    |
| A Port           | Out        | In  | HI-Z |
| B Port           | In         | Out | HI-Z |

## Am2947

AC ELECTRICAL CHARACTERISTICS ( $V_{CC} = 5.0V$ ,  $T_A = 25^\circ C$ )

| Parameters                           | Description  | Test Conditions  | Min | Typ<br>(Note 1) | Max | Units |
|--------------------------------------|--|--|-----|-----------------|-----|-------|
| A PORT DATA/MODE SPECIFICATIONS      |  |  |     |                 |     |       |
| tPDHLA                               | Propagation Delay to a Logical "0" from B Port to A Port                                   | CD = 0.4V, T/ $\overline{R}$ = 0.4V (Figure 1)<br>R <sub>1</sub> = 1k, R <sub>2</sub> = 5k, C <sub>1</sub> = 30pF  |     | 14              | 18  | ns    |
| tPDLHA                               | Propagation Delay to a Logical "1" from B Port to A Port                                   | CD = 0.4V, T/ $\overline{R}$ = 0.4V (Figure 1)<br>R <sub>1</sub> = 1k, R <sub>2</sub> = 5k, C <sub>1</sub> = 30pF  |     | 13              | 18  | ns    |
| tPLZA                                | Propagation Delay from a Logical "0" to 3-State from CD to A Port                          | B <sub>0</sub> to B <sub>7</sub> = 0.4V, T/ $\overline{R}$ = 0.4V (Figure 3)<br>S <sub>3</sub> = 1, R <sub>5</sub> = 1k, C <sub>4</sub> = 15pF               |     | 11              | 15  | ns    |
| tPHZA                                | Propagation Delay from a Logical "1" to 3-State from CD to A Port                          | B <sub>0</sub> to B <sub>7</sub> = 2.4V, T/ $\overline{R}$ = 0.4V (Figure 3)<br>S <sub>3</sub> = 0, R <sub>5</sub> = 1k, C <sub>4</sub> = 15pF               |     | 8               | 15  | ns    |
| tPZLA                                | Propagation Delay from 3-State to a Logical "0" from CD to A Port                          | B <sub>0</sub> to B <sub>7</sub> = 0.4V, T/ $\overline{R}$ = 0.4V (Figure 3)<br>S <sub>3</sub> = 1, R <sub>5</sub> = 1k, C <sub>4</sub> = 30pF               |     | 27              | 35  | ns    |
| tPZHA                                | Propagation Delay from 3-State to a Logical "1" from CD to A Port                          | B <sub>0</sub> to B <sub>7</sub> = 2.4V, T/ $\overline{R}$ = 0.4V (Figure 3)<br>S <sub>3</sub> = 0, R <sub>5</sub> = 5k, C <sub>4</sub> = 30pF               |     | 19              | 25  | ns    |
| B PORT DATA/MODE SPECIFICATIONS      |  |  |     |                 |     |       |
| tPDHLB                               | Propagation Delay to Logical "0" from A Port to B Port                                     | CD = 0.4V, T/ $\overline{R}$ = 2.4V (Figure 1)   |     | 18              | 23  | ns    |
|                                      |  | R <sub>1</sub> = 100Ω, R <sub>2</sub> = 1k, C <sub>1</sub> = 300pF   |     |                 |     |       |
|                                      |  | R <sub>1</sub> = 667Ω, R <sub>2</sub> = 5k, C <sub>1</sub> = 45pF  |     | 11              | 18  |       |
| tPDLHB                               | Propagation Delay to Logical "1" from A Port to B Port                                     | CD = 0.4V, T/ $\overline{R}$ = 2.4V (Figure 1)   |     | 16              | 23  | ns    |
|                                      |  | R <sub>1</sub> = 100Ω, R <sub>2</sub> = 1k, C <sub>1</sub> = 300pF   |     |                 |     |       |
|                                      |  | R <sub>1</sub> = 667Ω, R <sub>2</sub> = 5k, C <sub>1</sub> = 45pF  |     | 11              | 18  |       |
| tPLZB                                | Propagation Delay from a Logical "0" to 3-State from CD to B Port                          | A <sub>0</sub> to A <sub>7</sub> = 0.4V, T/ $\overline{R}$ = 2.4V (Figure 3)<br>S <sub>3</sub> = 1, R <sub>5</sub> = 1k, C <sub>4</sub> = 15pF               |     | 13              | 18  | ns    |
| tPHZB                                | Propagation Delay from a Logical "1" to 3-State from CD to B Port                          | A <sub>0</sub> to A <sub>7</sub> = 2.4V, T/ $\overline{R}$ = 2.4V (Figure 3)<br>S <sub>3</sub> = 0, R <sub>5</sub> = 1k, C <sub>4</sub> = 15pF               |     | 8               | 15  | ns    |
| tPZLB                                | Propagation Delay from 3-State to a Logical "0" from CD to B Port                          | A <sub>0</sub> to A <sub>7</sub> = 0.4V, T/ $\overline{R}$ = 2.4V (Figure 3)   |     | 32              | 40  | ns    |
|                                      |  | S <sub>3</sub> = 1, R <sub>5</sub> = 100Ω, C <sub>4</sub> = 300pF  |     |                 |     |       |
|                                      |  | S <sub>3</sub> = 1, R <sub>5</sub> = 667Ω, C <sub>4</sub> = 45pF   |     | 16              | 22  |       |
| tPZHB                                | Propagation Delay from 3-State to a Logical "1" from CD to B Port                          | A <sub>0</sub> to A <sub>7</sub> = 2.4V, T/ $\overline{R}$ = 2.4V (Figure 3)   |     | 26              | 35  | ns    |
|                                      |  | S <sub>3</sub> = 0, R <sub>5</sub> = 1k, C <sub>4</sub> = 300pF  |     |                 |     |       |
|                                      |  | S <sub>3</sub> = 0, R <sub>5</sub> = 5kΩ, C <sub>4</sub> = 45pF  |     | 14              | 22  |       |
| TRANSMIT/RECEIVE MODE SPECIFICATIONS |  |  |     |                 |     |       |
| tTRL                                 | Propagation Delay from Transmit Mode to Receive a Logical "0," T/ $\overline{R}$ to A Port | CD = 0.4V (Figure 2)<br>S <sub>1</sub> = 0, R <sub>4</sub> = 100Ω, C <sub>3</sub> = 5pF<br>S <sub>2</sub> = 1, R <sub>3</sub> = 1k, C <sub>2</sub> = 30pF    |     | 30              | 40  | ns    |
| tTRH                                 | Propagation Delay from Transmit Mode to Receive a Logical "1," T/ $\overline{R}$ to A Port | CD = 0.4V (Figure 2)<br>S <sub>1</sub> = 1, R <sub>4</sub> = 100Ω, C <sub>3</sub> = 5pF<br>S <sub>2</sub> = 0, R <sub>3</sub> = 5k, C <sub>2</sub> = 30pF    |     | 28              | 40  | ns    |
| tRTL                                 | Propagation Delay from Receive Mode to Transmit a Logical "0," T/ $\overline{R}$ to B Port | CD = 0.4V (Figure 2)<br>S <sub>1</sub> = 1, R <sub>4</sub> = 100Ω, C <sub>3</sub> = 300pF<br>S <sub>2</sub> = 0, R <sub>3</sub> = 300Ω, C <sub>2</sub> = 5pF |     | 31              | 40  | ns    |
| tRTH                                 | Propagation Delay from Receive Mode to Transmit a Logical "1," T/ $\overline{R}$ to B Port | CD = 0.4V (Figure 2)<br>S <sub>1</sub> = 0, R <sub>4</sub> = 1k, C <sub>3</sub> = 300pF<br>S <sub>2</sub> = 1, R <sub>3</sub> = 300Ω, C <sub>2</sub> = 5pF   |     | 28              | 40  | ns    |

Notes: 1. All typical values given are for  $V_{CC} = 5.0V$  and  $T_A = 25^\circ C$ .

2. Only one output at a time should be shorted.

## DEFINITION OF FUNCTIONAL TERMS

**A<sub>0</sub>-A<sub>7</sub>** A port inputs/outputs are receiver output drivers when  $T/\bar{R}$  is LOW and are transmit inputs when  $T/\bar{R}$  is HIGH.**B<sub>0</sub>-B<sub>7</sub>** B port inputs/outputs are transmit output drivers when  $T/\bar{R}$  is HIGH and receiver inputs when  $T/\bar{R}$  is LOW.**CD** Chip Disable forces all output drivers into 3-state when HIGH (same function as active LOW chip select, CS).**T/ $\bar{R}$**  Transmit/Receive direction control determines whether A port or B port drivers are in 3-state. With  $T/\bar{R}$  HIGH, A port is the input and B port is the output. With  $T/\bar{R}$  LOW, A port is the output and B port is the input.

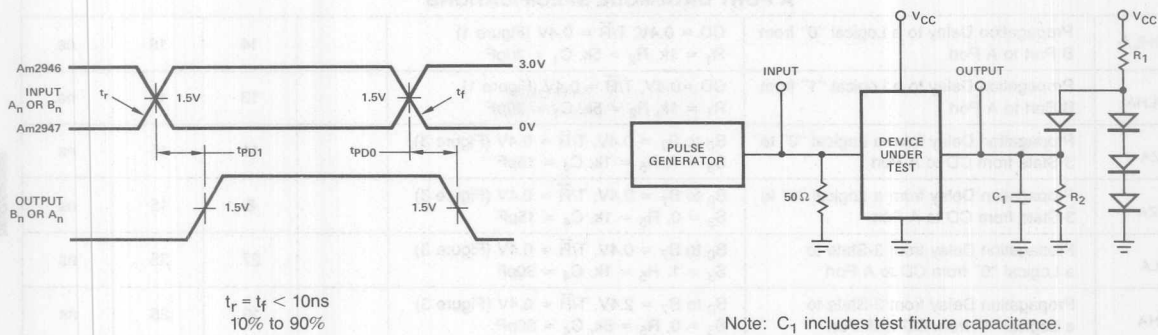


Figure 1. Propagation Delay from A Port to B Port or from B Port to A Port.

BLI-104

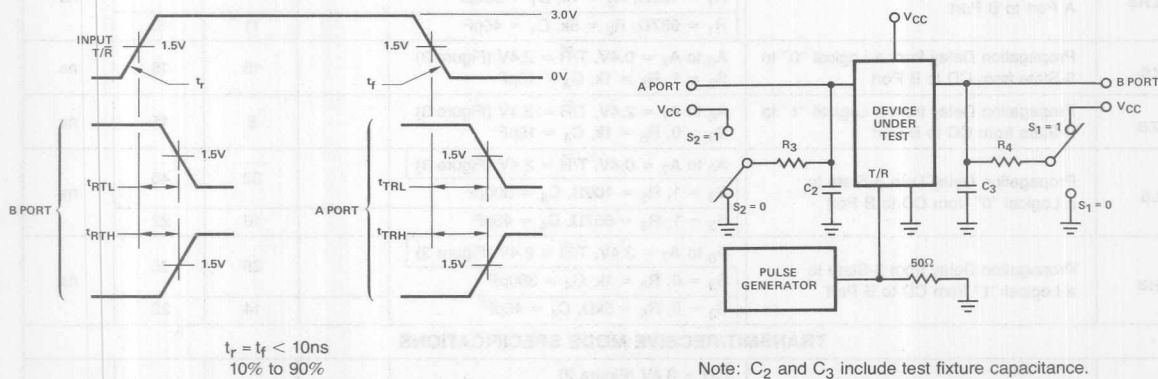


Figure 2. Propagation Delay from T/R to A Port or B Port.

BLI-105

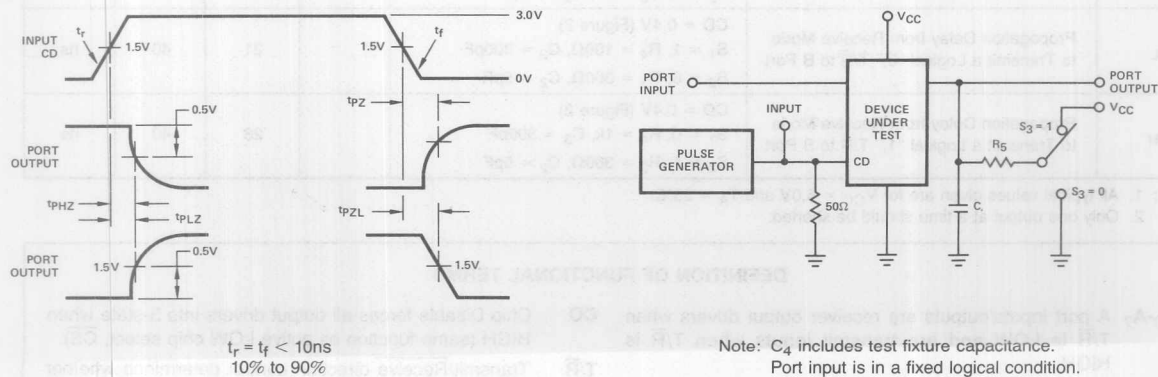


Figure 3. Propagation Delay from CD to A Port or B Port.

BLI-106



# Am2948 • Am2949

Octal 3-State Bidirectional Bus Transceivers

## ADVANCE INFORMATION

### DISTINCTIVE CHARACTERISTICS

- 8-bit bidirectional data flow reduces system package count
- 3-state inputs/outputs for interfacing with bus-oriented systems
- PNP inputs reduce input loading
- $V_{CC} - 1.15V$   $V_{OH}$  interfaces with TTL, MOS and CMOS
- 48mA, 300pF bus drive capability
- Am2948 has inverting transceivers
- Am2949 has non-inverting transceivers
- Separate TRANSMIT and RECEIVE enables
- 20-pin ceramic and molded DIP package
- Low power — 8mA per bidirectional bit
- Advanced Schottky processing
- Bus port stays in hi-impedance state during power up/down
- 100% product assurance screening to MIL-STD-883 requirements

### FUNCTIONAL DESCRIPTION

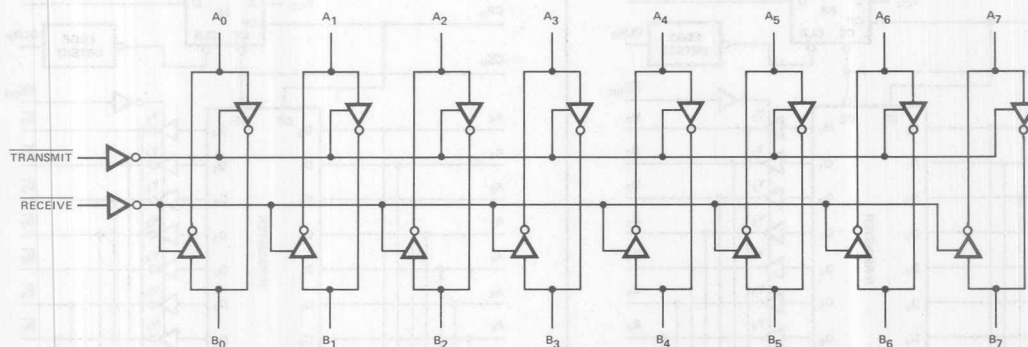
The Am2948 and Am2949 are 8-bit 3-state Schottky transceivers. They provide bidirectional drive for bus-oriented microprocessor and digital communications systems. Straight through bidirectional transceivers are featured, with 24mA drive capability on the A ports and 48mA bus drive capability on the B ports. PNP inputs are incorporated to reduce input loading.

Separate TRANSMIT and RECEIVE enables are provided for microprocessor systems with separated read and write control bus lines.

The output high voltage ( $V_{OH}$ ) is specified at  $V_{CC} - 1.15V$  minimum to allow interfacing with MOS, CMOS, TTL, ROM, RAM or microprocessors.

2

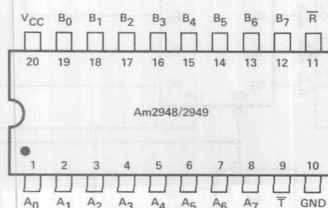
Am2949  
LOGIC DIAGRAM



Am2948 has inverting transceivers.

BLI-107

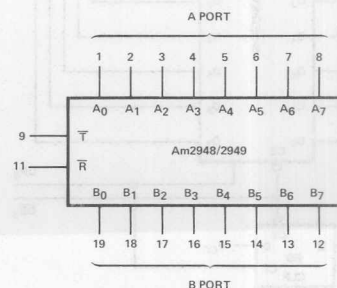
CONNECTION DIAGRAM  
Top View



Note: Pin 1 is marked for orientation.

BLI-108

LOGIC SYMBOL



$V_{CC}$  = Pin 20  
GND = Pin 10

BLI-109

# Am2950 • Am2951

## Eight-Bit Bidirectional I/O Ports

### DISTINCTIVE CHARACTERISTICS

- Eight-Bit, Bidirectional I/O Port with Handshake — Two eight-bit, back-to-back registers store data moving in both directions between two bidirectional busses.
- Register Full/Empty Flags — On-chip flag flip-flops provide data transfer handshaking signals.
- Separate Clock, Clock Enable and Three-State Output Enable for Each Register.
- Separate, Edge-Sensitive Clear Control for Each Flag Flip-Flop.
- Inverting and Non-Inverting Versions — The Am2950 provides non-inverting data outputs. The Am2951 provides inverting data outputs.
- 24mA Output Current Sink Capability.
- 100% Reliability Assurance Testing in Compliance with MIL-STD-883.

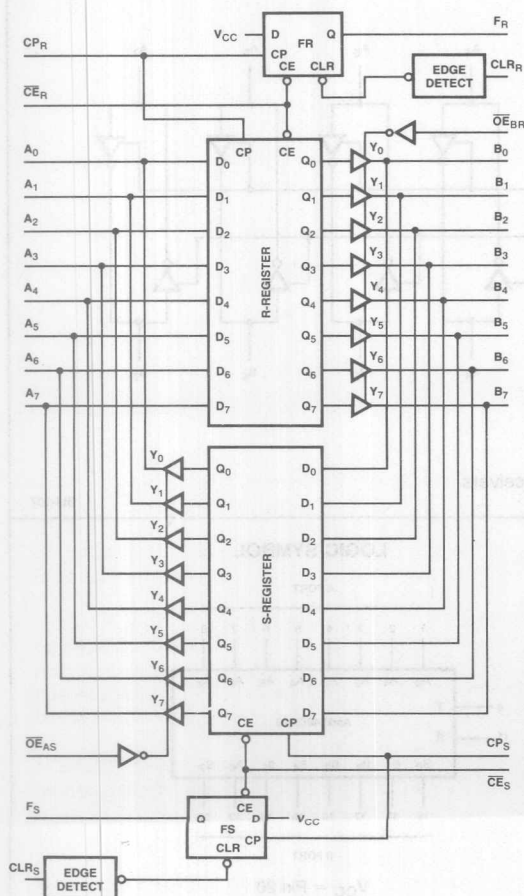
### GENERAL DESCRIPTION

The Am2950 and Am2951, members of Advanced Micro Devices Am2900 Family, are designed for use as parallel data I/O ports. Two eight-bit, back to back registers store data moving in both directions between two bidirectional, 3-state busses. On chip flag flip-flops, set automatically when a register is loaded, provide the handshaking signals required for demand-response data transfer.

Considerable flexibility is designed into the Am2950 • Am2951. Separate clock, clock enable and three-state output enable signals are provided for each register, and edge-sensitive clear inputs are provided for each flag flip-flop. A number of these circuits can be used for wider I/O ports. Both inverting and non-inverting versions are available.

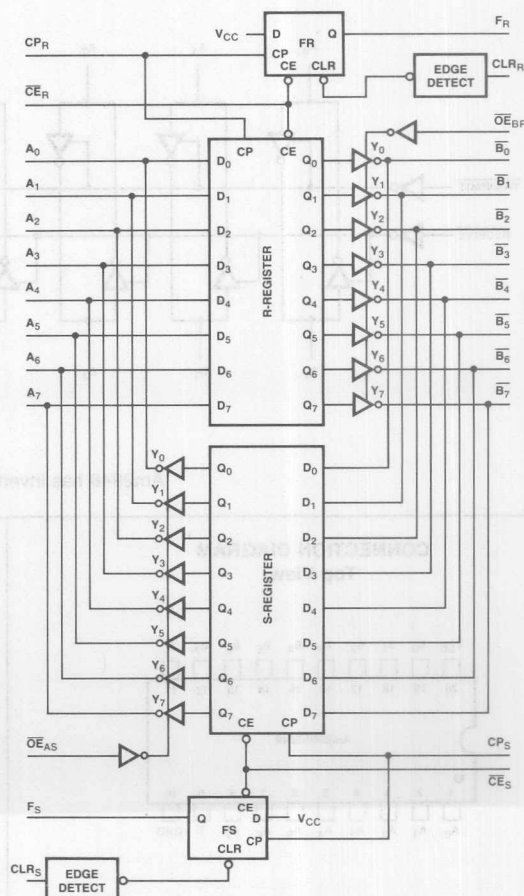
Twenty-four mA output current sink capability, sufficient for most three-state busses, is provided by the Am2950 • Am2951.

Am2950 BLOCK DIAGRAM

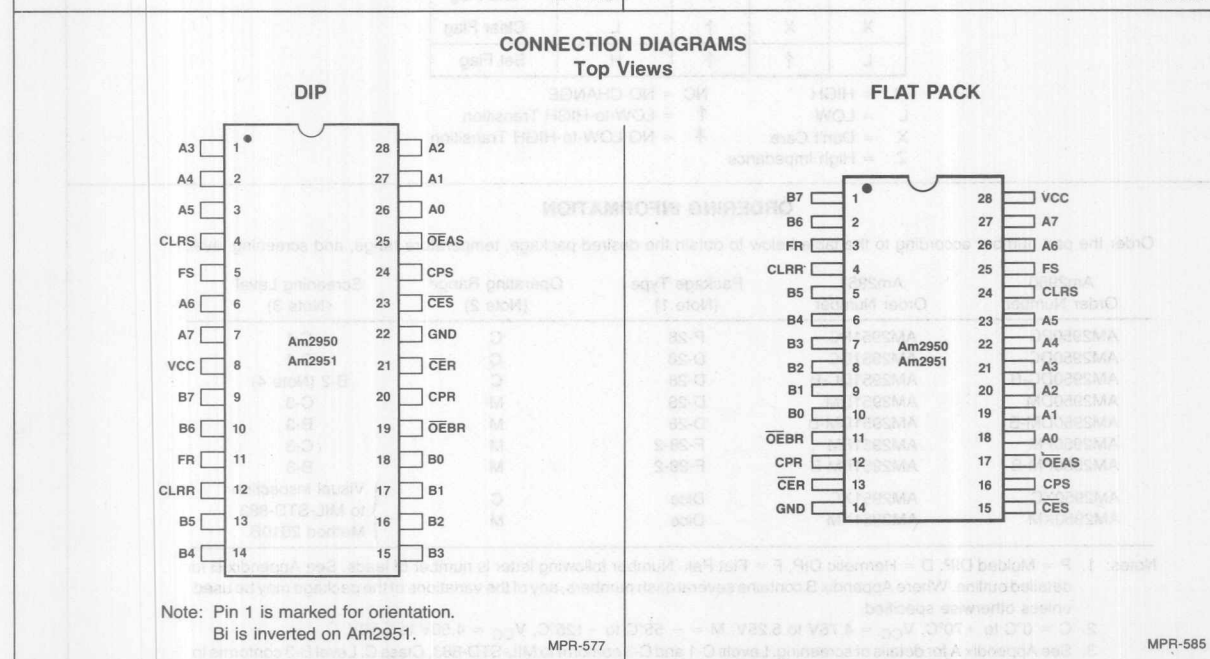
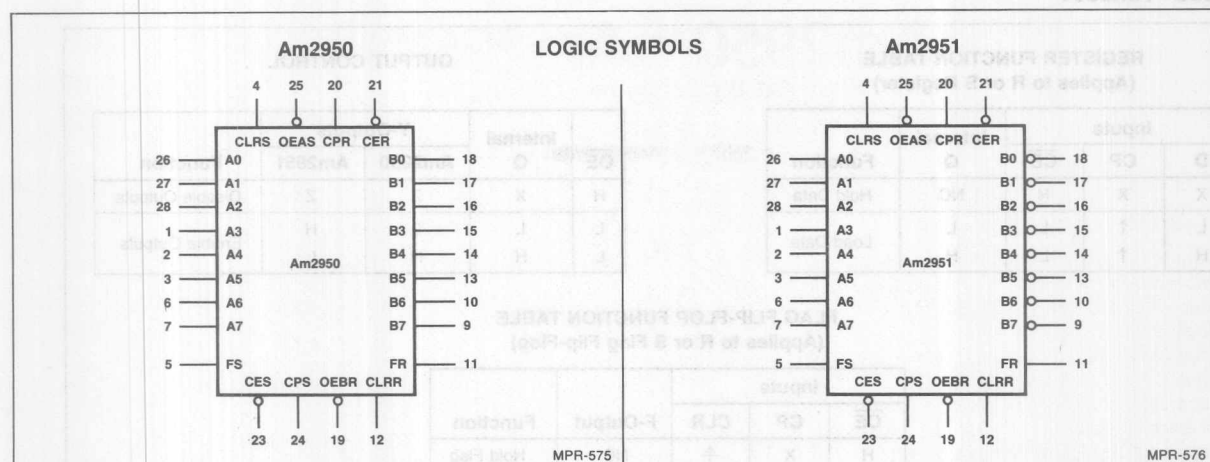


MPR-573

Am2951 BLOCK DIAGRAM



MPR-574

**DEFINITION OF FUNCTIONAL TERMS**

**A0-7** Eight bidirectional lines carrying the R Register inputs or S Register outputs.

**B0-7** Eight bidirectional lines carrying the S Register inputs or R Register outputs.

**CPR** The clock for the R Register and FR Flip-Flop. When  $\overline{\text{CER}}$  is LOW, data is entered into the R Register and the FR Flip-Flop is set on the LOW to HIGH transition of the CPR signal.

**$\overline{\text{CER}}$**  The Clock Enable for the R Register and FR Flip-Flop. When  $\overline{\text{CER}}$  is LOW, data is entered into the R Register and the FR Flip-Flop is set on the LOW to HIGH transition of the CPR signal. When  $\overline{\text{CER}}$  is HIGH, The R Register and FR Flip-Flop hold their contents, regardless of CPR signal transitions.

**$\overline{\text{OEBR}}$**  The Output Enable for the R Register. When  $\overline{\text{OEBR}}$  is LOW, The R Register three-state outputs are enabled onto the B0-7 lines. When  $\overline{\text{OEBR}}$  is HIGH, the R Register outputs are in the high-impedance state.

**FR** The FR Flip-Flop output.

**CLRR** The clear control for the FR Flip-Flop. The FR Flip-Flop is cleared on the LOW to HIGH transition of CLRR signal.

**CPS** The clock for the S Register and FS Flip-Flop. When  $\overline{\text{CES}}$  is LOW, data is entered into the S Register and the FS Flip-Flop is set on the LOW to HIGH transition of the CPS signal.

**$\overline{\text{CES}}$**  The clock enable for the S Register and FS Flip-Flop. When  $\overline{\text{CES}}$  is LOW, data is entered into the S Register and the FS Flip-Flop is set on the LOW to HIGH transition of the CPS signal. When  $\overline{\text{CES}}$  is HIGH, the S Register and FS Flip-Flop hold their contents, regardless of CPS signal transitions.

**$\overline{\text{OEAS}}$**  The output enable for the S Register. When  $\overline{\text{OEAS}}$  is LOW, the S Register three-state outputs are enabled onto the A0-7 lines. When  $\overline{\text{OEAS}}$  is HIGH, the S Register outputs are in the high-impedance state.

**FS** The FS Flip-Flop output.

**CLRS** The clear control for the FS Flip-Flop. The FS Flip-Flop is cleared on the LOW to HIGH transition of CLRS signal.

| Inputs |    |    | Internal<br>Q | Function  |
|--------|----|----|---------------|-----------|
| D      | CP | CE |               |           |
| X      | X  | H  | NC            | Hold Data |
| L      | ↑  | L  | L             | Load Data |
| H      | ↑  | L  | H             |           |

| OE | Internal<br>Q | Y-Outputs |        | Function        |
|----|---------------|-----------|--------|-----------------|
|    |               | Am2950    | Am2951 |                 |
| H  | X             | Z         | Z      | Disable Outputs |
| L  | L             | L         | H      | Enable Outputs  |
| L  | H             | H         | L      |                 |

**FLAG FLIP-FLOP FUNCTION TABLE**  
(Applies to R or S Flag Flip-Flop)

| Inputs |    |     | F-Output | Function   |
|--------|----|-----|----------|------------|
| CE     | CP | CLR |          |            |
| H      | X  | ↑   | NC       | Hold Flag  |
| X      | X  | ↑   | L        | Clear Flag |
| L      | ↑  | ↑   | H        | Set Flag   |

H = HIGH  
L = LOW  
X = Don't Care  
Z = High Impedance  
NC = NO CHANGE  
↑ = LOW-to-HIGH Transition  
↑ = NO LOW-to-HIGH Transition

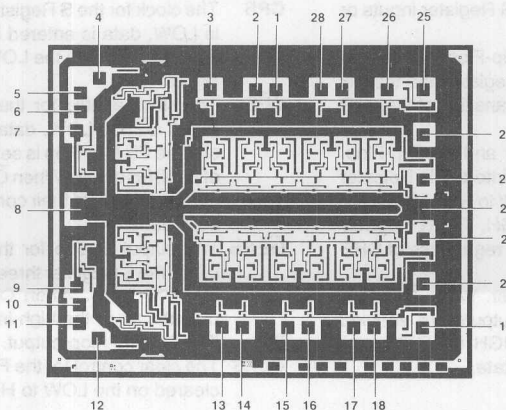
### ORDERING INFORMATION

Order the part number according to the table below to obtain the desired package, temperature range, and screening level.

| Am2950<br>Order Number | Am2951<br>Order Number | Package Type<br>(Note 1) | Operating Range<br>(Note 2) | Screening Level<br>(Note 3)                          |
|------------------------|------------------------|--------------------------|-----------------------------|--|
| AM2950PC               | AM2951PC               | P-28                     | C                           | C-1  |
| AM2950DC               | AM2951DC               | D-28                     | C                           | C-1  |
| AM2950DC-B             | AM2951DC-B             | D-28                     | C                           | B-2 (Note 4)   |
| AM2950DM               | AM2951DM               | D-28                     | M                           | C-3  |
| AM2950DM-B             | AM2951DM-B             | D-28                     | M                           | B-3  |
| AM2950FM               | AM2951FM               | F-28-2                   | M                           | C-3  |
| AM2950FM-B             | AM2951FM-B             | F-28-2                   | M                           | B-3  |
| AM2950XC               | AM2951XC               | Dice                     | C                           | Visual inspection<br>to MIL-STD-883<br>Method 2010B. |
| AM2950XM               | AM2951XM               | Dice                     | M                           |  |

- Notes: 1. P = Molded DIP, D = Hermetic DIP, F = Flat Pak. Number following letter is number of leads. See Appendix B for detailed outline. Where Appendix B contains several dash numbers, any of the variations of the package may be used unless otherwise specified.  
2. C = 0°C to +70°C,  $V_{CC} = 4.75V$  to 5.25V, M = -55°C to +125°C,  $V_{CC} = 4.50V$  to 5.50V.  
3. See Appendix A for details of screening. Levels C-1 and C-3 conform to MIL-STD-883, Class C. Level B-3 conforms to MIL-STD-883, Class B.  
4. 96 hour burn-in.

### METALLIZATION AND PAD LAYOUT



Numbers refer to DIP pin connection  
DIE SIZE 0.107" X 0.138"

**MAXIMUM RATINGS** (Above which the useful life may be impaired)

|   |                    |
|---|--------------------|
| Storage Temperature                                 | −65°C to +150°C    |
| Temperature (Ambient) Under Bias                    | −55°C to +125°C    |
| Supply Voltage to Ground Potential Continuous       | −0.5V to +7.0V     |
| DC Voltage Applied to Outputs for High Output State | −0.5V to +VCC max. |
| DC Input Voltage                                    | −0.5V to +5.5V     |
| DC Output Current, Into Outputs                     | 30mA               |
| DC Input Current                                    | −30mA to +5.0mA    |

2

**OPERATING RANGE**

| Part Number     | Range | Temperature                      | VCC  |
|-----------------|-------|----------------------------------|--|
| Am2950/51PC, DC | COM'L | T <sub>A</sub> = 0°C to +70°C    | VCC = 5.0V ±5% (MIN. = 4.75V, MAX. = 5.25V)  |
| Am2950/51DM, FM | MIL   | T <sub>C</sub> = −55°C to +125°C | VCC = 5.0V ±10% (MIN. = 4.50V, MAX. = 5.50V) |

**Am2950, Am2951****DC CHARACTERISTICS OVER OPERATING RANGE**

| DC CHARACTERISTICS OVER OPERATING RANGE |                                       |  |            |                     |                      |          | Typ. |       |       |
|---|---------------------------------------|--|------------|---------------------|----------------------|----------|------|-------|-------|
| Parameters                              | Description                           | Test Conditions (Note 1)                             |            |                     | Min.                 | (Note 2) | Max. | Units |       |
| VOH                                     | Output HIGH Voltage                   | VCC = MIN.<br>VIN = VIH or VIL                       | FR, FS     | IOH = −1mA          | 2.4                  | 3.4      |      | Volts |       |
|   |                                       |  | A0-7, B0-7 | MIL, IOH = −2mA     | 2.4                  | 3.4      |      |       |       |
|   |                                       |  |            | COM'L, IOH = −6.5mA | 2.4                  | 3.4      |      |       |       |
| VOL                                     | Output LOW Voltage (Note 5)           | VCC = MIN.<br>VIN = VIH or VIL                       | FR, FS     | IOL = 12mA          |                      |          | 0.5  | Volts |       |
|   |                                       |  | A0-7, B0-7 | MIL IOL = 16mA      |                      |          | 0.5  |       |       |
|   |                                       |  |            | COM'L IOL = 24mA    |                      |          | 0.5  |       |       |
| VIH                                     | Input HIGH Level                      | Guaranteed input logical HIGH voltage for all inputs |            |                     |                      | 2.0      |      |       | Volts |
| VIL                                     | Input LOW Level                       | Guaranteed input logical LOW voltage for all inputs  |            |                     |                      |          |      | 0.8   | Volts |
| VI                                      | Input Clamp Voltage                   | VCC = MIN., IIN = −18mA                              |            |                     |                      |          |      | −1.5  | Volts |
| IIL                                     | Input LOW Current                     | VCC = MAX., VIN = 0.5V                               | A0-7, B0-7 |                     |                      |          | −250 | μA    |       |
|   |                                       |  | CLRR, CLRS |                     |                      |          | −2.0 | mA    |       |
|   |                                       |  | Others     |                     |                      |          | −360 | μA    |       |
| IIH                                     | Input HIGH Current                    | VCC = MAX., VIN = 2.7V                               | A0-7, B0-7 |                     |                      |          | 70   | μA    |       |
|   |                                       |  | CLRR, CLRS |                     |                      |          | 100  |       |       |
|   |                                       |  | Others     |                     |                      |          | 20   |       |       |
| II                                      | Input HIGH Current                    | VCC = MAX., VIN = 5.5V                               |            |                     |                      |          |      | 1.0   | mA    |
| IO                                      | Output Off-state Leakage Current      | VCC = MAX.   | A0-7, B0-7 | V0 = 2.4V           |                      |          | 70   | μA    |       |
|   |                                       |  |            | V0 = 0.4V           |                      |          | −250 |       |       |
| ISC                                     | Output Short Circuit Current (Note 3) | VCC = MAX.   |            |                     |                      | −30      |      | −85   | mA    |
| ICC                                     | Power Supply Current (Notes 4, 6)     | VCC = MAX.   |            | TA = 25°C           |                      | 156      | 263  | mA    |       |
|   |                                       |  |            | COM'L               | TA = 0°C to +70°C    |          |      |       | 275   |
|   |                                       |  | TA = +70°C |                     |                      |          | 228  |       |       |
|   |                                       |  | MIL        |                     | TC = −55°C to +125°C |          |      |       | 309   |
|   |                                       |  |            | TC = +125°C         |                      |          | 202  |       |       |

- Notes: 1. For conditions shown as MIN. or MAX., use the appropriate value specified under Electrical Characteristics for the applicable device type.  
2. Typical limits are at VCC = 5.0V, 25°C ambient and maximum loading.  
3. Not more than one output should be shorted at a time. Duration of the short circuit test should not exceed one second.  
4. ICC is measured with all inputs at 4.5V and all outputs open.  
5. The sum of IOL into Ai and Bi for each i must not exceed 32mA COM'L, 24mA MIL at a given point in time.  
6. Worst case ICC is at minimum temperature.



## SWITCHING CHARACTERISTICS

The tables below define the Am 2950 • Am2951 switching characteristics. Tables A are set-up and hold times relative to a clock LOW-to-HIGH transition. Tables B are propagation delays. Tables C are recovery times. Tables D are pulse-width requirements. Tables E are enable/disable times. All measurements are made at 1.5V with input levels at 0V or 3V. All values are in ns with RL on Ai and Bi = 220Ω and RL on FS and FR = 300Ω. CL = 50pF except output disable times which are specified at CL = 5pF.

TYPICAL ROOM TEMPERATURE CHARACTERISTICS ( $T_A = 25^\circ\text{C}$ ,  $V_{CC} = 5.0\text{V}$ )
**A. Set-up and Hold Times**  
 (With respect to clock  
 LOW-to-HIGH transition.)

| Input                   | With Respect To | ts | th |
|-------------------------|-----------------|----|----|
| A0-7                    | CPS             | 2  | 0  |
| B0-7                    | CPR             | 2  | 0  |
| $\overline{\text{CES}}$ | CPS             | 9  | 0  |
| $\overline{\text{CER}}$ | CPR             | 9  | 0  |

## B. Propagation Delays

| Input | A0-7 | B0-7 | FS | FR |
|-------|------|------|----|----|
| CPS   | 15   | —    | 13 | —  |
| CPR   | —    | 15   | —  | 13 |
| CLRS  | —    | —    | 11 | —  |
| CLRR  | —    | —    | —  | 11 |

## C. Recovery Times

| From | To  | tREC |
|------|-----|------|
| CLRS | CPS | 17   |
| CLRR | CPR | 17   |

## D. Pulse-Width Requirements

| Input | Min. LOW Pulse Width | Min. HIGH Pulse Width |
|-------|----------------------|-----------------------|
| CPS   | 15                   | 15                    |
| CPR   | 15                   | 15                    |
| CLRS  | 15                   | 15                    |
| CLRR  | 15                   | 15                    |

## E. Enable/Disable Times

| From                     | To   | Disable | Enable |
|--------------------------|------|---------|--------|
| $\overline{\text{OEAS}}$ | A0-7 | 15      | 16     |
| $\overline{\text{OEBR}}$ | B0-7 | 15      | 16     |

GUARANTEED ROOM TEMPERATURE CHARACTERISTICS ( $T_A = 25^\circ\text{C}$ ,  $V_{CC} = 5.0\text{V}$ )

## A. Set-up and Hold Times.

| Input                   | With Respect To | ts | th |
|-------------------------|-----------------|----|----|
| A0-7                    | CPS             |    |    |
| B0-7                    | CPR             |    |    |
| $\overline{\text{CES}}$ | CPS             |    |    |
| $\overline{\text{CER}}$ | CPR             |    |    |

## B. Propagation Delays

| Input | A0-7 | B0-7 | FS | FR |
|-------|------|------|----|----|
| CPS   |      | —    |    | —  |
| CPR   | —    |      | —  |    |
| CLRS  | —    | —    |    | —  |
| CLRR  | —    | —    | —  |    |

## C. Recovery Times

| From | To  | tREC |
|------|-----|------|
| CLRS | CPS |      |
| CLRR | CPR |      |

## D. Pulse-Width Requirements

| Input | Min. LOW Pulse Width | Min. HIGH Pulse Width |
|-------|----------------------|-----------------------|
| CPS   |                      |                       |
| CPR   |                      |                       |
| CLRS  |                      |                       |
| CLRR  |                      |                       |

## E. Enable/Disable Times

| From                     | To   | Disable | Enable |
|--------------------------|------|---------|--------|
| $\overline{\text{OEAS}}$ | A0-7 |         |        |
| $\overline{\text{OEBR}}$ | B0-7 |         |        |

# **GUARANTEED CHARACTERISTICS OVER COMMERCIAL OPERATING RANGE**

( $T_A = 0^\circ\text{C}$  to  $+70^\circ\text{C}$ ,  $V_{CC} = 4.75$  to  $5.25\text{V}$ )

## **A. Set-up and Hold Times.**

| Input                   | With Respect To | $t_s$ | $t_h$ |
|-------------------------|-----------------|-------|-------|
| A0-7                    | CPS             | 7     | 5     |
| B0-7                    | CPR             | 7     | 5     |
| $\overline{\text{CES}}$ | CPS             | 15    | 4     |
| $\overline{\text{CER}}$ | CPR             | 15    | 4     |

## **B. Propagation Delays**

| Input | A0-7 | B0-7 | FS | FR |
|-------|------|------|----|----|
| CPS   | 26   | —    | 20 | —  |
| CPR   | —    | 26   | —  | 20 |
| CLRS  | —    | —    | 22 | —  |
| CLRR  | —    | —    | —  | 22 |

## **C. Recovery Times**

| From | To  | $t_{\text{REC}}$ |
|------|-----|------------------|
| CLRS | CPS | 31               |
| CLRR | CPR | 31               |

## **D. Pulse-Width Requirements**

| Input | Min. LOW Pulse Width | Min. HIGH Pulse Width |
|-------|----------------------|-----------------------|
| CPS   | 20                   | 20                    |
| CPR   | 20                   | 20                    |
| CLRS  | 20                   | 20                    |
| CLRR  | 20                   | 20                    |

## **E. Enable/Disable Times**

| From                     | To   | Disable | Enable |
|--------------------------|------|---------|--------|
| $\overline{\text{OEAS}}$ | A0-7 | 22      | 27     |
| $\overline{\text{OEER}}$ | B0-7 | 22      | 27     |

# **GUARANTEED CHARACTERISTICS OVER MILITARY OPERATING RANGE**

( $T_C = -55^\circ\text{C}$  to  $+125^\circ\text{C}$ ,  $V_{CC} = 4.5$  to  $5.5\text{V}$ )

## **A. Set-up and Hold Times.**

| Input                   | With Respect To | $t_s$ | $t_h$ |
|-------------------------|-----------------|-------|-------|
| A0-7                    | CPS             | 11    | 8     |
| B0-7                    | CPR             | 11    | 8     |
| $\overline{\text{CES}}$ | CPS             | 15    | 4     |
| $\overline{\text{CER}}$ | CPR             | 15    | 4     |

## **B. Propagation Delays**

| Input | A0-7 | B0-7 | FS | FR |
|-------|------|------|----|----|
| CPS   | 28   | —    | 20 | —  |
| CPR   | —    | 28   | —  | 20 |
| CLRS  | —    | —    | 22 | —  |
| CLRR  | —    | —    | —  | 22 |

## **C. Recovery Times**

| From | To  | $t_{\text{REC}}$ |
|------|-----|------------------|
| CLRS | CPS | 34               |
| CLRR | CPR | 34               |

## **D. Pulse-Width Requirements**

| Input | Min. LOW Pulse Width | Min. HIGH Pulse Width |
|-------|----------------------|-----------------------|
| CPS   | 20                   | 20                    |
| CPR   | 20                   | 20                    |
| CLRS  | 20                   | 20                    |
| CLRR  | 20                   | 20                    |

## **E. Enable/Disable Times**

| From                     | To   | Disable | Enable |
|--------------------------|------|---------|--------|
| $\overline{\text{OEAS}}$ | A0-7 | 24      | 28     |
| $\overline{\text{OEER}}$ | B0-7 | 24      | 28     |

## Am2950 • Am2951

allows it to be used in any type of computer system, including Am2900, 8080, 8085, 8086, Z80, and Z8000 systems.

Figure 1 shows an Am2950 used to store data moving in both directions between a bidirectional system data bus and a bidirectional

Figure 2 shows a multiple I/O port system using Am2950's. Two Am2950's are used at each port to interface the 16-bit system data bus. The Am2950 flags are used to generate I/O interrupt requests.

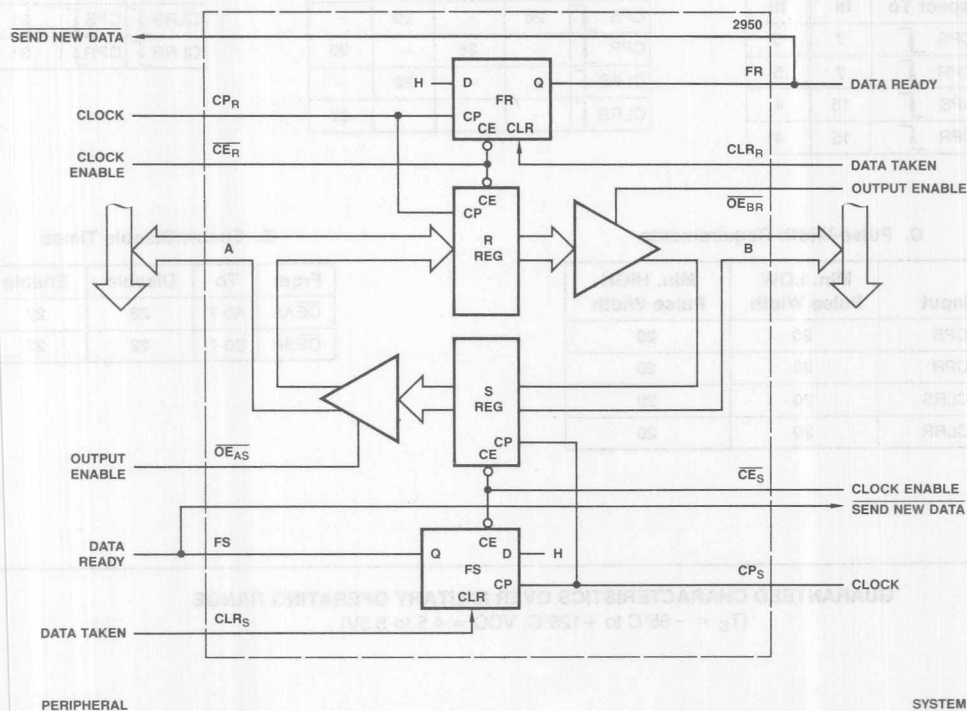


Figure 1. A Bidirectional I/O Port with Handshaking Using the Am2950.

MPR-578

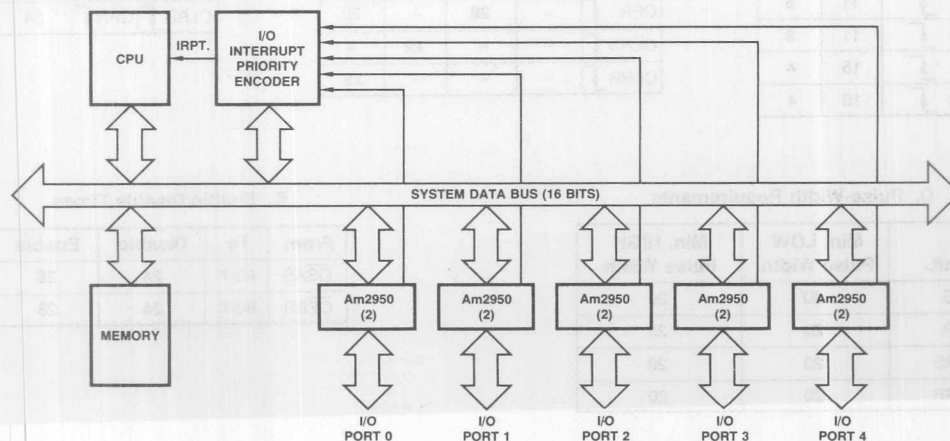


Figure 2. Multiple I/O Port System.

MPR-579

## 2

# Am2954 • Am2955

## ELECTRICAL CHARACTERISTICS

The Following Conditions Apply Unless Otherwise Specified:

|                  |                  |  |  |
|------------------|------------------|--|--|
| Am2954XC, DC, PC | Am2955XC, DC, PC | $T_A = 0 \text{ to } 70^\circ\text{C}$     | $V_{CC} = 4.75 \text{ to } 5.25\text{V}$ |
| Am2954XM, DM, FM | Am2955XM, DM, FM | $T_C = -55 \text{ to } +125^\circ\text{C}$ | $V_{CC} = 4.50 \text{ to } 5.50\text{V}$ |

## DC CHARACTERISTICS OVER OPERATING RANGE

| Parameters | Description                               | Test Conditions (Note 1)  | Min  | Typ<br>(Note 2)   | Max       | Units         |
|------------|---|---|--|-------------------|-----------|---------------|
| $V_{OH}$   | Output HIGH Voltage                       | $V_{CC} = \text{MIN}$<br>$V_{IN} = V_{IH} \text{ or } V_{IL}$       | MIL, $I_{OH} = -2.0\text{mA}$<br>COM'L, $I_{OH} = -6.5\text{mA}$ | 2.4<br>3.4<br>3.1 |           | Volts         |
| $V_{OL}$   | Output LOW Voltage                        | $V_{CC} = \text{MIN}$<br>$V_{IN} = V_{IH} \text{ or } V_{IL}$       | $I_{OL} = 20\text{mA}$<br>$I_{OL} = 32\text{mA}$                 |                   | .45<br>.5 | Volts         |
| $V_{IH}$   | Input HIGH Level                          | Guaranteed input logical HIGH voltage for all inputs                | 2.0  |                   |           | Volts         |
| $V_{IL}$   | Input LOW Level                           | Guaranteed input logical LOW voltage for all inputs                 |  |                   | 0.8       | Volts         |
| $V_I$      | Input Clamp Voltage                       | $V_{CC} = \text{MIN}$ , $I_{IN} = -18\text{mA}$                     |  |                   | -1.2      | Volts         |
| $I_{IL}$   | Input LOW Current                         | $V_{CC} = \text{MAX}$ , $V_{IN} = 0.5\text{V}$                      |  |                   | -250      | $\mu\text{A}$ |
| $I_{IH}$   | Input HIGH Current                        | $V_{CC} = \text{MAX}$ , $V_{IN} = 2.7\text{V}$                      |  |                   | 50        | $\mu\text{A}$ |
| $I_I$      | Input HIGH Current                        | $V_{CC} = \text{MAX}$ , $V_{IN} = 5.5\text{V}$                      |  |                   | 1.0       | mA            |
| $I_{OZ}$   | Off-State (High-Impedance) Output Current | $V_{CC} = \text{MAX}$<br>$V_O = 0.5\text{V}$<br>$V_O = 2.4\text{V}$ |  |                   | -50<br>50 | $\mu\text{A}$ |
| $I_{SC}$   | Output Short Circuit Current (Note 3)     | $V_{CC} = \text{MAX}$   | -40  |                   | -100      | mA            |
| $I_{CC}$   | Power Supply Current (Note 4)             | $V_{CC} = \text{MAX}$   |  | 90                | 140       | mA            |

Notes: 1. For conditions shown as MIN or MAX use the appropriate value specified under Electrical Characteristics for the applicable device type.

2. Typical limits are at  $V_{CC} = 5.0\text{V}$ ,  $25^\circ\text{C}$  ambient and maximum loading.

3. Not more than one output should be shorted at a time. Duration of the short circuit test should not exceed one second.

4. Am2954 measured at CLK = LOW-to-HIGH,  $\overline{OE} = \text{HIGH}$ , and all data inputs are LOW.

Am2955 measured at CLK = LOW-to-HIGH,  $\overline{OE} = \text{HIGH}$ , and all data inputs are LOW.

## MAXIMUM RATINGS (Above which the useful life may be impaired)

|   |                                |
|---|--------------------------------|
| Storage Temperature   | -65 to +150°C                  |
| Temperature (Ambient) Under Bias                                | -55 to +125°C                  |
| Supply Voltage to Ground Potential (Pin 16 to Pin 8) Continuous | -0.5 to +7.0V                  |
| DC Voltage Applied to Outputs for HIGH Output State             | -0.5V to $+V_{CC} \text{ max}$ |
| DC Input Voltage  | -0.5 to +5.5V                  |
| DC Output Current, Into Outputs                                 | 30mA                           |
| DC Input Current  | -30 to +5.0mA                  |



## ORDERING INFORMATION

Order the part number according to the table below to obtain the desired package, temperature range, and screening level.

| Am2954<br>Order Number | Am2955<br>Order Number | Package Type<br>(Note 1) | Operating Range<br>(Note 2) | Screening Level<br>(Note 3)                          |
|------------------------|------------------------|--------------------------|-----------------------------|--|
| AM2954PC               | AM2955PC               | P-20-1                   | C                           | C-1  |
| AM2954DC               | AM2955DC               | D-20-1                   | C                           | C-1  |
| AM2954DC-B             | AM2955DC-B             | D-20-1                   | C                           | B-1  |
| AM2954DM               | AM2955DM               | D-20-1                   | M                           | C-3  |
| AM2954DM-B             | AM2955DM-B             | D-20-1                   | M                           | B-3  |
| AM2954FM               | AM2955FM               | F-20                     | M                           | C-3  |
| AM2954FM-B             | AM2955FM-B             | F-20                     | M                           | B-3  |
| AM2954XC               | AM2955XC               | Dice                     | C                           | Visual inspection<br>to MIL-STD-883<br>Method 2010B. |
| AM2954XM               | AM2955XM               | Dice                     | M                           |  |

## Notes:

1. P = Molded DIP, D = Hermetic DIP, F = Flat Pak. Number following letter is number of leads. See Appendix B for detailed outline. Where Appendix B contains several dash numbers, any of the variations of the package may be used unless otherwise specified.
2. C = 0 to 70°C,  $V_{CC}$  = 4.75V to 5.25V, M = -55 to + 125°C,  $V_{CC}$  = 4.50V to 5.50V.
3. See Appendix A for details of screening. Levels C-1 and C-3 conform to MIL-STD-883, Class C. Level B-3 conforms to MIL-STD-883, Class B.

## DEFINITION OF FUNCTIONAL TERMS

$D_i$  The D flip-flop data inputs (Am2954, non-inverting).

$\bar{D}_i$  The D flip-flop data inputs (Am2955, inverting).

**CP** Clock Pulse for the register. Enters data on the LOW-to-HIGH transition.

$Y_i$  The register three-state outputs (Am2954, non-inverting).

**$\bar{OE}$**  Output Control. An active-LOW three-state control used to enable the outputs. A HIGH level input forces the outputs to the high impedance (off) state.

## FUNCTION TABLE

| Function         | Inputs     |       |              |                    | Internal | Outputs |
|------------------|------------|-------|--------------|--------------------|----------|---------|
|                  | $\bar{OE}$ | Clock | Am2954 $D_i$ | Am2955 $\bar{D}_i$ | $Q_i$    | $Y_i$   |
| Hi-Z             | H          | L     | X            | X                  | NC       | Z       |
|                  | H          | H     | X            | X                  | NC       | Z       |
| LOAD<br>REGISTER | L          | ↑     | L            | H                  | L        | L       |
|                  | L          | ↑     | H            | L                  | H        | H       |
|                  | H          | ↑     | L            | H                  | L        | Z       |
|                  | H          | ↑     | H            | L                  | H        | Z       |

H = HIGH

L = LOW

X = Don't Care

NC = No Change

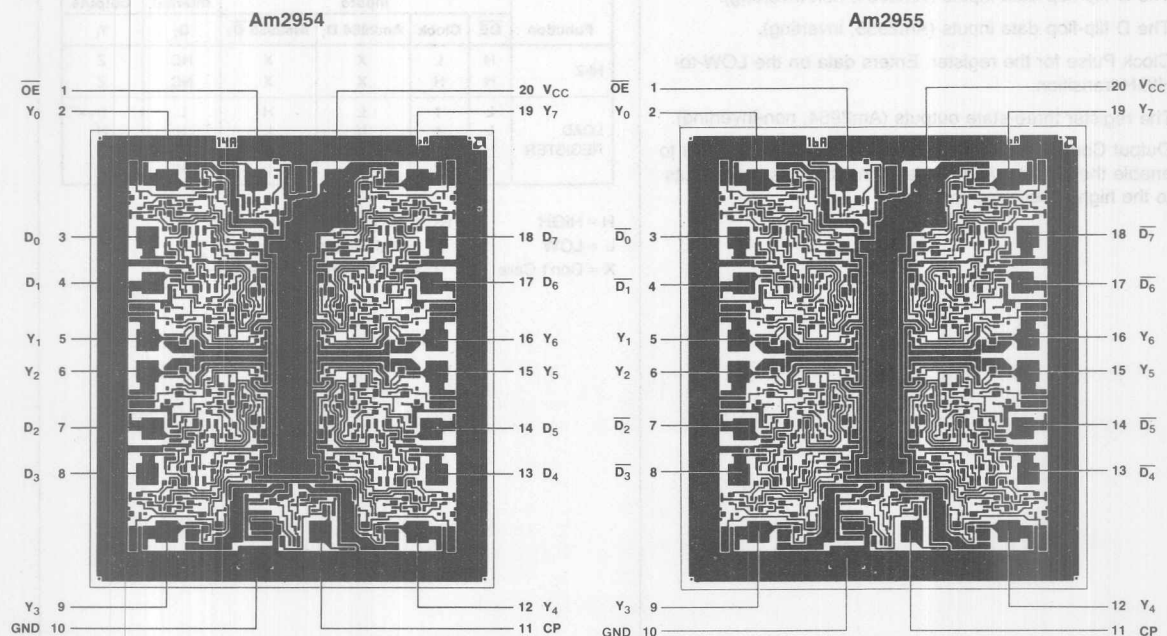
Z = High Impedance

↑ = LOW-to-HIGH transition

| Parameters | Description                      | Am2954 • Am2955 |     |     | Units | Test Conditions                   |
|------------|----------------------------------|-----------------|-----|-----|-------|-----------------------------------|
|            |                                  | Min             | Typ | Max |       |                                   |
| $t_{PLH}$  | Clock to Output, $Y_i$           |                 | 8   | 15  | ns    | $C_L = 15pF$<br>$R_L = 280\Omega$ |
| $t_{PHL}$  |                                  |                 | 11  | 17  | ns    |                                   |
| $t_{ZH}$   | $\overline{OE}$ to $Y_i$         |                 | 8   | 15  | ns    |                                   |
| $t_{ZL}$   |                                  |                 | 11  | 18  | ns    |                                   |
| $t_{HZ}$   | $\overline{OE}$ to $Y_i$         |                 | 5   | 9   | ns    | $C_L = 5pF$<br>$R_L = 280\Omega$  |
| $t_{LZ}$   |                                  |                 | 7   | 12  | ns    |                                   |
| $t_{pw}$   | Clock Pulse Width                | HIGH            | 6   |     | ns    | $C_L = 15pF$<br>$R_L = 280\Omega$ |
|            |                                  | LOW             | 7.3 |     | ns    |                                   |
| $t_S$      | Data to Clock                    |                 | 5   |     | ns    |                                   |
| $t_H$      |                                  |                 | 2   |     | ns    |                                   |
| $f_{max}$  | Maximum Clock Frequency (Note 1) | 75              | 100 |     | MHz   |                                   |

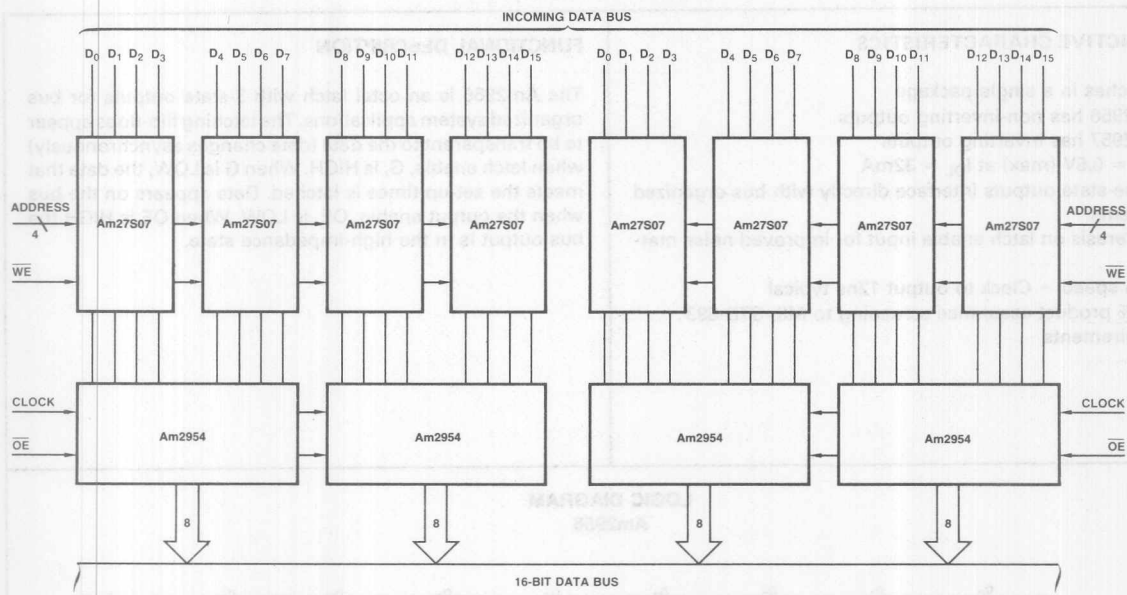
Note: 1. Per industry convention,  $f_{max}$  is the worst case value of the maximum device operating frequency with no constraints on  $t_r$ ,  $t_f$ , pulse width or duty cycle.

### Metalization and Pad Layouts



DIE SIZE 0.096" X 0.083"

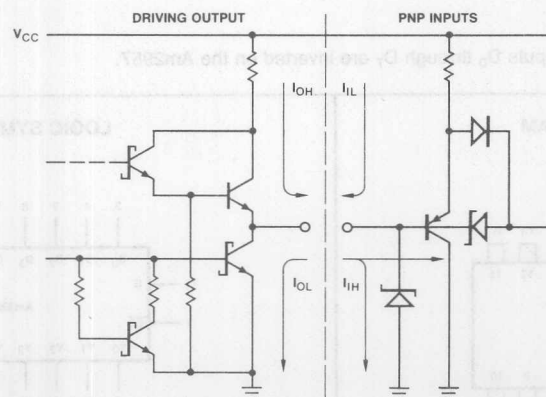
## APPLICATION



Dual 16-word by 16-bit non-inverting high-speed data buffer.

BLI-113

**SCHOTTKY INPUT/OUTPUT  
CURRENT INTERFACE CONDITIONS**



Note: Actual current flow direction shown.

BLI- 14

# Am2956 • Am2957

Octal Latches with Three-State Outputs

## ADVANCED DATA

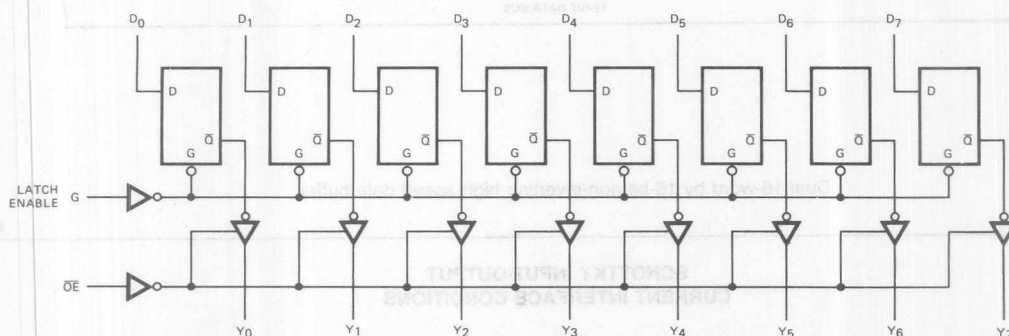
### DISTINCTIVE CHARACTERISTICS

- 8 latches in a single package
- Am2956 has non-inverting outputs
- Am2957 has inverting outputs
- $V_{OL} = 0.5V$  (max) at  $I_{OL} = 32mA$
- Three-state outputs interface directly with bus organized systems
- Hysteresis on latch enable input for improved noise margin
- High speed – Clock to output 12ns typical
- 100% product assurance screening to MIL-STD-883 requirements

### FUNCTIONAL DESCRIPTION

The Am2956 is an octal latch with 3-state outputs for bus organized system applications. The latching flip-flops appear to be transparent to the data (data changes asynchronously) when latch enable, G, is HIGH. When G is LOW, the data that meets the set-up times is latched. Data appears on the bus when the output enable, OE, is LOW. When OE is HIGH the bus output is in the high-impedance state.

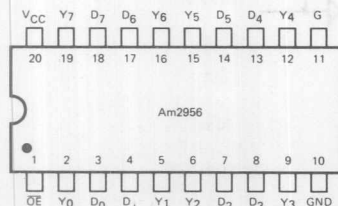
### LOGIC DIAGRAM Am2956



Inputs  $D_0$  through  $D_7$  are inverted on the Am2957.

MPR-360

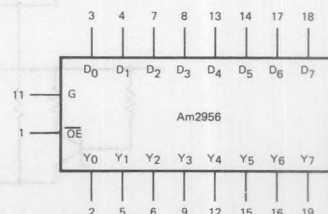
### CONNECTION DIAGRAM Top View



Note: Pin 1 is marked for orientation.

MPR-361

### LOGIC SYMBOL



$V_{CC}$  = Pin 20  
GND = Pin 10

MPR-362

# Am2958 • Am2959

Octal Buffers/Line Drivers/Line Receivers with Three-State Outputs

2

## DISTINCTIVE CHARACTERISTICS

- Three-state outputs drive bus lines directly
- Advanced Schottky processing
- Hysteresis at inputs improve noise margin
- PNP inputs reduce D.C. loading on bus lines
- $V_{OL}$  of 0.55V at 65mA for commercial-range product; 48mA for military-range product
- Data-to-output propagation delay times:
  - Inverting – 7.0ns MAX
  - Non-inverting – 9.0ns MAX
- Enable-to-output – 15.0ns MAX
- 100% reliability assurance testing in compliance with MIL-STD-883
- 20-pin hermetic and molded DIP packages

## FUNCTIONAL DESCRIPTION

These buffers/line drivers, used as memory-address drivers, clock drivers, and bus oriented transmitters/receivers, provide improved PC board density. The outputs of the commercial temperature range versions have 64mA sink and 15mA source capability, which can be used to drive terminated lines down to 133Ω. The outputs of the military temperature range versions have 48mA sink and 12mA source current capability.

Featuring 0.2V minimum guaranteed hysteresis at each low-current PNP data input, they provide improved noise rejection and high-fan-out outputs to restore Schottky TTL levels completely.

The Am2958 and Am2959 have four buffers enabled from one common line, and the other four buffers enabled from another common line. The Am2958 is inverting, while the Am2959 presents true data at the outputs.

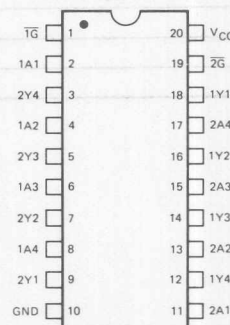
## CONNECTION DIAGRAMS Top Views

Am2958



BLI-137

Am2959



BLI-138

## ORDERING INFORMATION

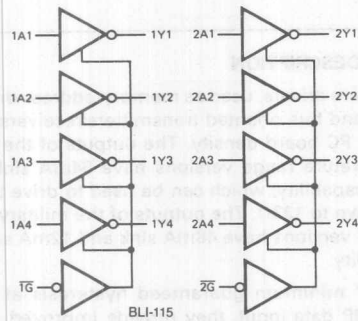
Order the part number according to the table below to obtain the desired package, temperature range, and screening level.

| Am2958<br>Order Number | Am2959<br>Order Number | Package Type<br>(Note 1) | Operating Range<br>(Note 2) | Screening Level<br>(Note 3)                          |
|------------------------|------------------------|--------------------------|-----------------------------|--|
| AM2958PC               | AM2959PC               | P-20-1                   | C                           | C-1  |
| AM2958DC               | AM2959DC               | D-20-1                   | C                           | C-1  |
| AM2958DC-B             | AM2959DC-B             | D-20-1                   | C                           | B-1  |
| AM2958DM               | AM2959DM               | D-20-1                   | M                           | C-3  |
| AM2958DM-B             | AM2959DM-B             | D-20-1                   | M                           | B-3  |
| Am2958XC               | Am2959XC               | Dice                     | C                           | Visual inspection<br>to MIL-STD-883<br>Method 2010B. |
| Am2958XM               | Am2959XM               | Dice                     | M                           |  |

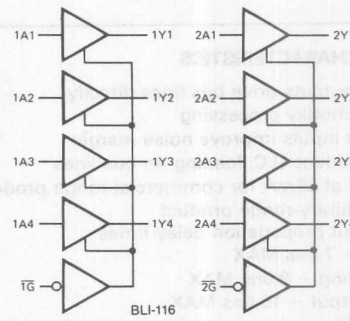
- Notes: 1. P = Molded DIP, D = Hermetic DIP, F = Flat Pak. Number following letter is number of leads. See Appendix B for detailed outline. Where Appendix B contains several dash numbers, any of the variations of the package may be used unless otherwise specified.
2. C = 0 to 70°C,  $V_{CC}$  = 4.75V to 5.25V, M = -55 to +125°C,  $V_{CC}$  = 4.50V to 5.50V.
3. See Appendix A for details of screening. Levels C-1 and C-3 conform to MIL-STD-883, Class C. Level B-3 conforms to MIL-STD-883.



Am2958



Am2959

**MAXIMUM RATINGS** above which the useful life may be impaired

|   |                                |
|---|--------------------------------|
| Storage Temperature                                 | -65°C to +150°C                |
| Temperature (Ambient) Under Bias                    | -55°C to +125°C                |
| Supply Voltage to Ground Potential                  | -0.5V to +7.0V                 |
| DC Voltage Applied to Outputs for HIGH Output State | -0.5V to +V <sub>CC</sub> max. |
| DC Input Voltage                                    | -0.5V to +7.0V                 |
| DC Output Current                                   | 150mA                          |
| DC Input Current                                    | -30mA to +5.0mA                |

## ELECTRICAL CHARACTERISTICS

The Following Conditions Apply Unless Otherwise Noted:

|                |   |                                      |                                      |
|----------------|---|--------------------------------------|--------------------------------------|
| Am2958 (MIL)   | $T_A = -55^{\circ}\text{C}$ to $+125^{\circ}\text{C}$ | $V_{CC}(\text{MIN.}) = 4.50\text{V}$ | $V_{CC}(\text{MAX.}) = 5.50\text{V}$ |
| Am2959 (COM'L) | $T_A = 0^{\circ}\text{C}$ to $+70^{\circ}\text{C}$    | $V_{CC}(\text{MIN.}) = 4.75\text{V}$ | $V_{CC}(\text{MAX.}) = 5.25\text{V}$ |

## ELECTRICAL CHARACTERISTICS OVER OPERATING TEMPERATURE RANGE

| Parameters | Description   | Test Conditions (Note 1)   | Min.  | Typ.<br>(Note 2) | Max. | Units         |
|------------|---|--|-------|------------------|------|---------------|
| $V_{IH}$   | High-Level Input Voltage                                |  | 2.0   |                  |      | Volts         |
| $V_{IL}$   | Low-Level Input Voltage                                 |  |       |                  | 0.8  | Volts         |
| $V_{IK}$   | Input Clamp Voltage                                     | $V_{CC} = \text{MIN.}, I_I = -18\text{mA}$   |       |                  | -1.2 | Volts         |
|            | Hysteresis ( $V_{T+} - V_{T-}$ )                        | $V_{CC} = \text{MIN.}$   | 0.2   | 0.4              |      | Volts         |
| $V_{OH}$   | High-Level Output Voltage                               | $V_{CC} = \text{MIN.}$<br>COM'L, $I_{OH} = -1\text{mA}$  | 2.7   |                  |      | Volts         |
|            |   | $V_{IL} = 0.8\text{V}$<br>$I_{OH} = -3\text{mA}$   | 2.4   | 3.4              |      |               |
|            |   | $V_{CC} = \text{MIN.}$<br>MIL, $I_{OH} = -12\text{mA}$   | 2.0   |                  |      |               |
|            |   | $V_{IL} = 0.5\text{V}$<br>COM'L, $I_{OH} = -15\text{mA}$   | 2.0   |                  |      |               |
| $V_{OL}$   | Low-Level Output Voltage                                | $V_{CC} = \text{MIN.}$<br>MIL, $I_{OL} = 48\text{mA}$  |       |                  | 0.55 | Volts         |
|            |   | $V_{IL} = 0.8\text{V}$<br>COM'L, $I_{OL} = 64\text{mA}$  |       |                  | 0.55 |               |
| $I_{OZH}$  | Off-State Output Current,<br>High-Level Voltage Applied | $V_{CC} = \text{MAX.}$<br>$V_{IH} = 2.0\text{V}$<br>$V_{IL} = 0.8\text{V}$<br>$V_O = 2.4\text{V}$                |       |                  | 50   | $\mu\text{A}$ |
| $I_{OZL}$  | Off-State Output Current,<br>Low-Level Voltage Applied  | $V_O = 0.5\text{V}$  |       |                  | -50  |               |
| $I_I$      | Input Current at Maximum<br>Input Voltage               | $V_{CC} = \text{MAX.}, V_I = 5.5\text{V}$  |       |                  | 1.0  | $\text{mA}$   |
| $I_{IH}$   | High-Level Input Current, Any Input                     | $V_{CC} = \text{MAX.}, V_{IH} = 2.7\text{V}$   |       |                  | 50   | $\mu\text{A}$ |
| $I_{IL}$   | Low-Level Input Current                                 | Any A<br>$V_{CC} = \text{MAX.}, V_{IL} = 0.5\text{V}$  |       |                  | -400 | $\mu\text{A}$ |
|            |   | Any G  |       |                  | -2.0 |               |
| $I_{OS}$   | Short-Circuit Output Current (Note 3)                   | $V_{CC} = \text{MAX.}$   | -50   |                  | -225 | $\text{mA}$   |
| $I_{CC}$   | Supply Current  | All Outputs<br>HIGH<br>Am2958<br>All Outputs<br>LOW<br>Outputs at Hi-Z<br>$V_{CC} = \text{MAX.}$<br>Outputs open | MIL   | 80               | 123  | $\text{mA}$   |
|            |   |  | COM'L | 80               | 135  |               |
|            |   |  | MIL   | 100              | 145  |               |
|            |   |  | COM'L | 100              | 150  |               |
|            |   |  | MIL   | 100              | 145  |               |
|            |   |  | COM'L | 100              | 150  |               |
|            |   | All Outputs<br>HIGH<br>Am2959<br>All Outputs<br>LOW<br>Outputs at Hi-Z<br>$V_{CC} = \text{MAX.}$<br>Outputs open | MIL   | 95               | 147  | $\text{mA}$   |
|            |   |  | COM'L | 95               | 160  |               |
|            |   |  | MIL   | 120              | 170  |               |
|            |   |  | COM'L | 120              | 180  |               |
|            |   |  | MIL   | 120              | 170  |               |
|            |   |  | COM'L | 120              | 180  |               |

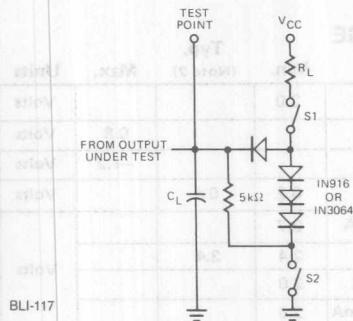
Notes: 1. For conditions shown as MIN. or MAX., use the appropriate value specified under recommended operating conditions.

2. All typical values are  $V_{CC} = 5.0\text{V}$ ,  $T_A = 25^{\circ}\text{C}$ .

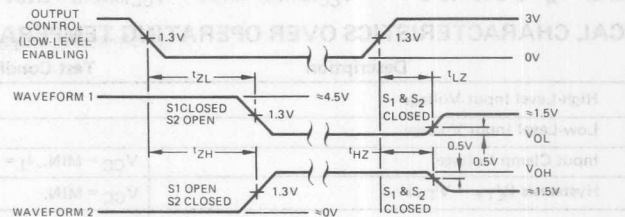
3. Not more than one output should be shorted at a time, and duration of the short-circuit should not exceed one second.

SWITCHING CHARACTERISTICS ( $V_{CC} = 5\text{V}$ ,  $T_A = 25^{\circ}\text{C}$ )

| Parameter | Description   | Test Conditions                                 | Am2958 |      |      | Am2959 |      |      | Units |
|-----------|---|---|--------|------|------|--------|------|------|-------|
|           |   |   | Min.   | Typ. | Max. | Min.   | Typ. | Max. |       |
| $t_{PLH}$ | Propagation Delay Time,<br>Low-to-High-Level Output | $C_L = 50\text{pF}$ , $R_L = 90\Omega$ (Note 3) |        | 4.5  | 7.0  |        | 6.0  | 9.0  | ns    |
| $t_{PHL}$ | Propagation Delay Time,<br>High-to-Low-Level Output |   |        | 4.5  | 7.0  |        | 6.0  | 9.0  | ns    |
| $t_{ZL}$  | Output Enable Time to Low Level                     |   |        | 10   | 15   |        | 10   | 15   | ns    |
| $t_{ZH}$  | Output Enable Time to High Level                    | $C_L = 50\text{pF}$ , $R_L = 90\Omega$ (Note 3) |        | 6.5  | 10   |        | 8.0  | 12   | ns    |
| $t_{LZ}$  | Output Disable Time from Low Level                  |   |        | 10   | 15   |        | 10   | 15   | ns    |
| $t_{HZ}$  | Output Disable Time from High Level                 |   |        | 6.0  | 9.0  |        | 6.0  | 9.0  | ns    |

LOAD CIRCUIT FOR  
THREE-STATE OUTPUTS

BLI-117

VOLTAGE WAVEFORMS  
ENABLE AND DISABLE TIMES, THREE-STATE OUTPUTS

BLI-118

- Notes:
1. Waveform 1 is for an output with internal conditions such that the output is low except when disabled by the output control.
  2. Waveform 2 is for an output with internal conditions such that the output is high except when disabled by the output control.
  3. In the examples above, the phase relationships between inputs and outputs have been chosen arbitrarily.  $PRR \leq 1.0\text{MHz}$ ,  $Z_{OUT} \approx 50\Omega$  and  $t_r \leq 2.5\text{ns}$ ,  $t_f \leq 2.5\text{ns}$ .

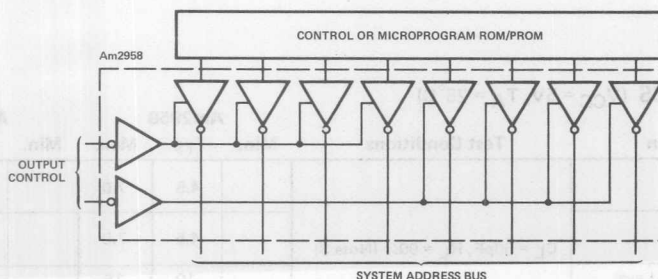
## FUNCTION TABLES

Am2958

| INPUTS    |   | OUTPUT |
|-----------|---|--------|
| $\bar{G}$ | A | Y      |
| H         | X | Z      |
| L         | H | L      |
| L         | L | H      |

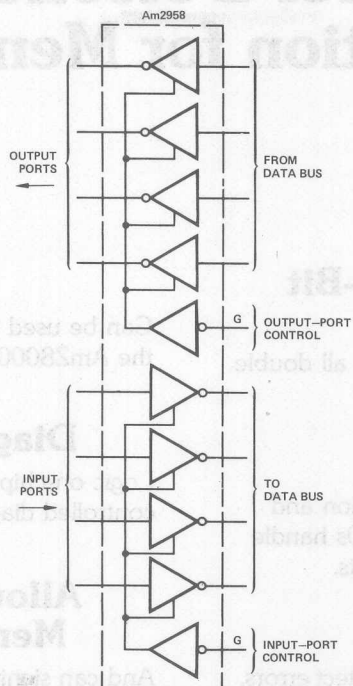
Am2959

| INPUTS    |   | OUTPUT |
|-----------|---|--------|
| $\bar{G}$ | A | Z      |
| H         | X | Z      |
| L         | H | H      |
| L         | L | L      |

Am2958 USED AS SYSTEM BUS DRIVER —  
4-BIT ORGANIZATION CAN BE APPLIED TO HANDLE BINARY OR BCD

BLI-119

## APPLICATIONS (Cont.)

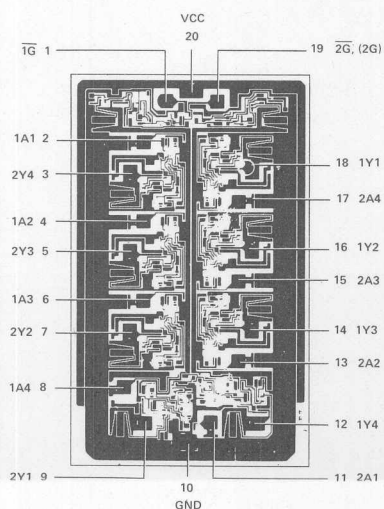
INDEPENDENT 4-BIT BUS DRIVERS/RECEIVERS  
IN A SINGLE PACKAGE

2

BLI-120

## Metallization and Pad Layout

## Am2958 • Am2959



DIE SIZE 0.077" X 0.124"

# Am2960

## Fast Error Detection and Correction for Memories

### Corrects All Single-Bit Errors

Corrects all single bit errors. Detects all double and some triple bit errors.

### Expandable

One Am2960 provides Error Detection and Correction for 16-bits. Two Am2960s handle 32 bits; four Am2960s handle 64 bits.

### Fast

Design objective of 30ns typical to detect errors, and 50ns to correct for 16-bits.

### Flexible

Can be used with Am2900-based designs, the AmZ8000 or other CPUs.

### Diagnostics Built-In

Logic on-chip for device test and software-controlled diagnostics.

### Allows for Increased Memory Reliability

And can significantly reduce field servicing costs.



# Am2960

## Cascadable 16-Bit Error Detection and Correction Unit

### ADVANCED DATA

#### DISTINCTIVE CHARACTERISTICS

- **Modified Hamming Code**  
Detects multiple errors and corrects single bit errors in a parallel data word. Ideal for use in dynamic memory systems.
- **Expandable**  
One Am2960 provides EDC on 16-bit data words.  
Two Am2960s provide EDC on 32-bit data words.  
Four Am2960s provide EDC on 64-bit data words.
- **Syndromes provided.**  
The Am2960 makes available the syndrome bits when an error occurs, so the location of memory faults can be logged.
- **Microprocessor compatible**  
The Am2960 is designed to work with Z8000 microprocessor systems as well as high performance 2900 designs.
- **Advanced circuit and process technologies**  
Newest 2900 LSI techniques provide very high performance.  
Data-in to error detection typically 30ns  
Data-in to correct data out typically 50ns
- **Built-in Diagnostics**  
Extra logic on the chip provides diagnostic functions to be used during device test and for system diagnostics.

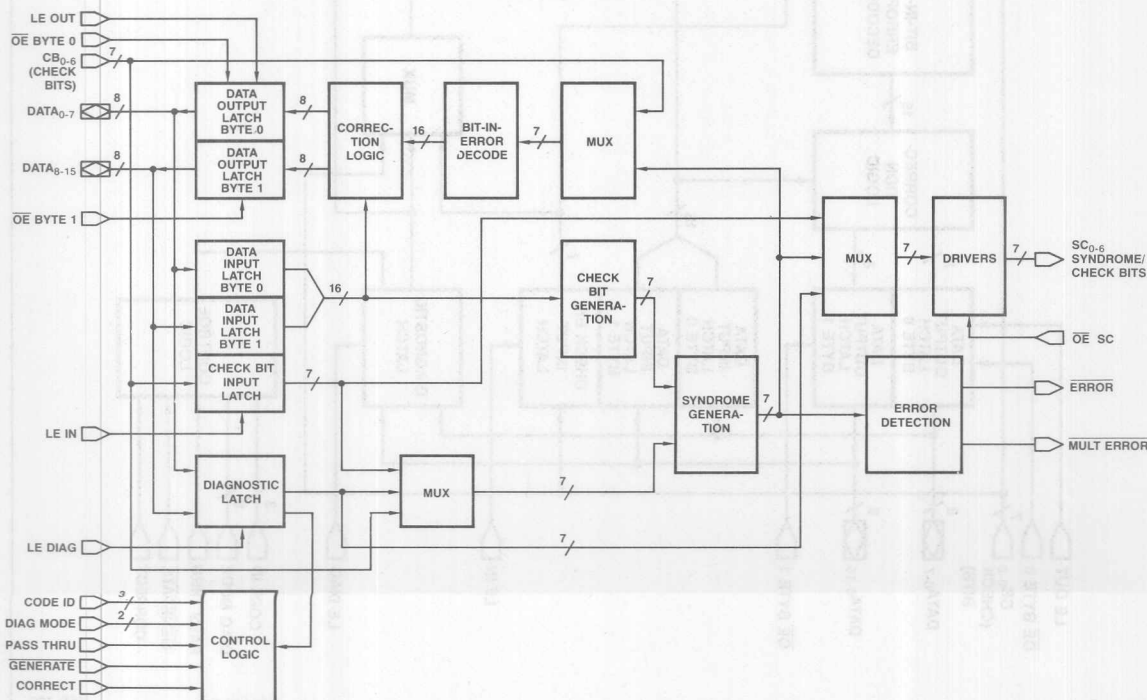
#### GENERAL DESCRIPTION

The Am2960 Error Detection and Correction Unit (EDC) contains the logic necessary to generate check bits on a 16-bit data field according to a modified Hamming Code, and to correct the data word when check bits are supplied. Operating on data read from memory, the Am2960 will correct any single bit error and will detect all double and some triple bit errors. For 16-bit words, 6 check bits are used. The Am2960 is expandable to operate on 32-bit words (7 check bits) and 64-bit words (8 check bits). In all configurations, the device makes the error syndrome available on separate outputs for data logging.

The Am2960 also features two diagnostic modes, in which diagnostic data can be forced into portions of the chip to simplify device testing and to execute system diagnostic functions. The product is supplied in a 48 lead hermetic DIP package.

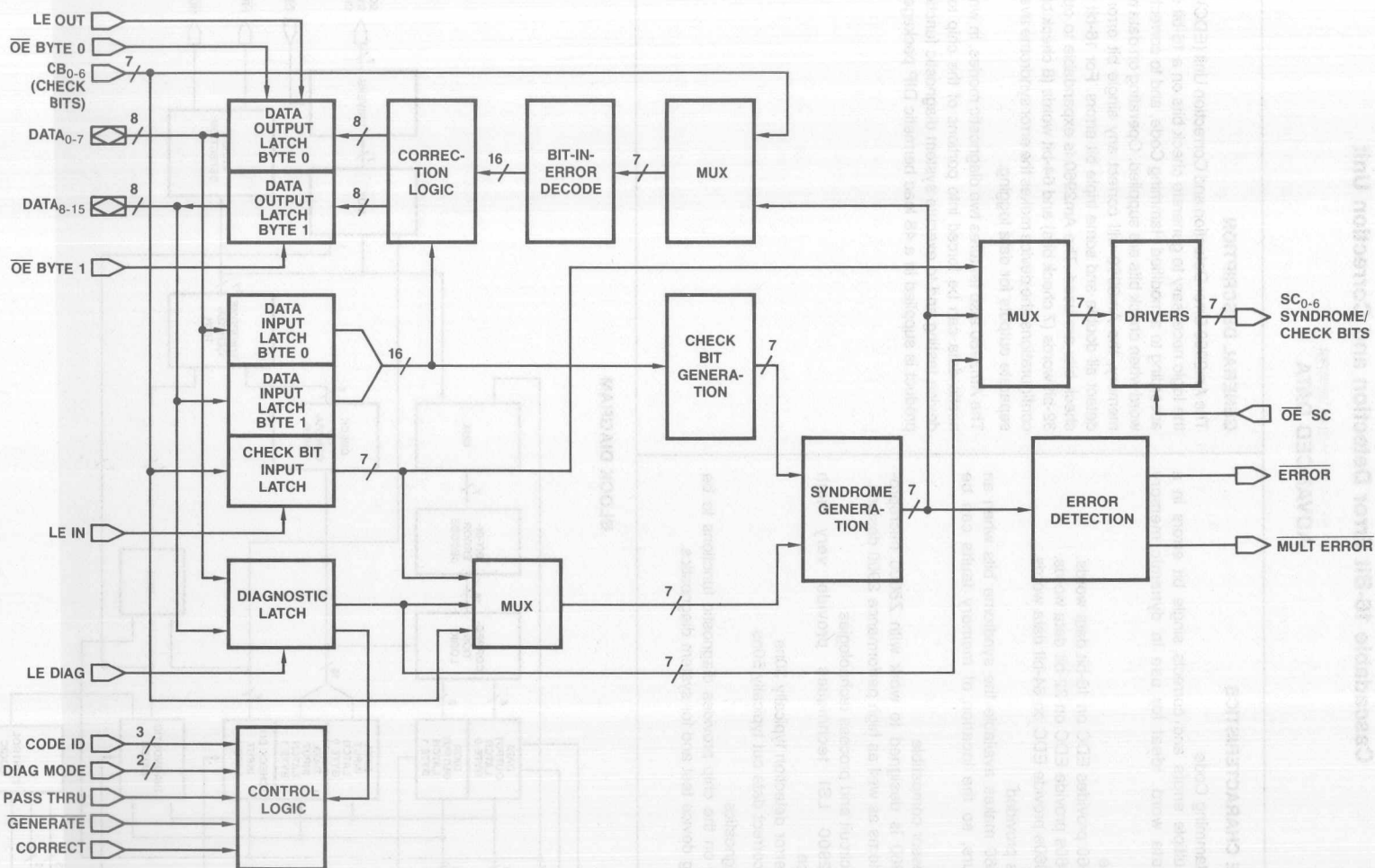
2

#### BLOCK DIAGRAM



MPR-729

## BLOCK DIAGRAM



## EDC Architecture

The EDC Unit is a powerful 16-bit cascadable slice used for check bit generation, error detection, error correction and diagnostics.

As shown in the block diagram, the device consists of the following:

- Data Input Latch
- Check Bit Input Latch
- Check Bit Generation Logic
- Syndrome Generation Logic
- Error Detection Logic
- Error Correction Logic
- Data Output Latch
- Diagnostic Latch
- Control Logic

### Data Input Latch

16 bits of data are loaded from the bidirectional DATA lines under control of the Latch Enable input, LE IN. Depending on the control mode the input data is either used for check bit generation or error detection/correction.

### Check Bit Input Latch

Seven check bits are loaded under control of LE IN. Check bits are used in the Error Detection and Error Correction modes.

### Check Bit Generation Logic

This block generates the appropriate check bits for the 16 bits of data in the Data Input Latch. The check bits are generated according to a modified Hamming code.

### Syndrome Generation Logic

In both Error Detection and Error Correction modes, this logic block compares the check bits read from memory against a newly generated set of check bits produced for the data read in from memory. If both sets of check bits match, then there are no errors. If there is a mismatch, then one or more of the data or check bits is in error.

The syndrome bits are produced by an exclusive-OR of the two sets of check bits. If the two sets of check bits are identical

(meaning there are no errors) the syndrome bits will be all zeroes. If there are errors, the syndrome bits can be decoded to determine the number of errors and the bit-in-error.

### Error Detection Logic

This section decodes the syndrome bits generated by the Syndrome Generation Logic. If there are no errors in either the input data or check bits, the **ERROR** and **MULTI ERROR** outputs remain HIGH. If one or more errors are detected, **ERROR** goes LOW. If two or more errors are detected, both **ERROR** and **MULTI ERROR** go LOW.

### Error Correction Logic

For single errors, the Error Correction Logic complements (corrects) the single data bit in error. This corrected data is loadable into the Data Output Latch, which can then be read onto the bidirectional data lines. If the single error is one of the check bits, the correction logic does not place corrected check bits on the syndrome/check bit outputs. If the corrected check bits are needed the EDC must be switched to Generate Mode.

### Data Output Latch

The Data Output Latch is used for storing the result of an error correction operation. The latch is loaded from the correction logic under control of the Data Output Latch Enable, LE OUT. The Data Output Latch may also be loaded directly from the Data Input Latch under control of the PASS THRU control input.

The Data Output Latch is split into two 8-bit (byte) latches which may be enabled independently for reading onto the bidirectional data lines.

### Diagnostic Latch

This is a 16-bit latch loadable from the bidirectional data lines under control of the Diagnostic Latch Enable, LE DIAG. The Diagnostic Latch contains check bit information in one byte and control information in the other byte. The Diagnostic Latch is used for driving the device when in Internal Control Mode, or for supplying check bits when in one of the Diagnostic Modes.

### Control Logic

The control logic determines the specific mode the device operates in. Normally the control logic is driven by external control inputs. However, in Internal Control Mode, the control signals are instead read from the Diagnostic Latch.

**DATA<sub>0-15</sub>**

16 bidirectional data lines. They provide input to the Data Input Latch and Diagnostic Latch, and receive output from the Data Output Latch. DATA<sub>0</sub> is the least significant bit; DATA<sub>15</sub> the most significant.

**CB<sub>0-6</sub>**

Seven Check Bit input lines. The check bit lines are used to input check bits for error detection. Also used to input syndrome bits for error correction in 32 and 64-bit configurations.

**LE IN**

Latch Enable – Data Input Latch. Controls latching of the input data. When HIGH the Data Input Latch and Check Bit Input Latch follow the input data and input check bits. When LOW, the Data Input Latch and Check Bit Input Latch are latched to their previous state.

**GENERATE**

Generate Check Bits input. When this input is LOW the EDC is in the Check Bit Generate Mode. When HIGH the EDC is in the Detect Mode or Correct Mode.

In the Generate Mode the circuit generates the check bits or partial check bits specific to the data in the Data Input Latch. The generated check bits are placed on the SC outputs.

In the Detect or Correct Modes the EDC detects single and multiple errors, and generates syndrome bits based upon the contents of the Data Input Latch and Check Bit Input Latch. In Correct Mode, single-bit errors are also automatically corrected – corrected data is placed at the inputs of the Data Output Latch. The syndrome result is placed on the SC outputs and indicates in a coded form the number of errors and the bit-in-error.

**SC<sub>0-6</sub>**

Syndrome/Check Bit outputs. These seven lines hold the check/partial-check bits when the EDC is in Generate Mode, and will hold the syndrome/partial syndrome bits when the device is in Detect or Correct Modes. These are 3-state outputs.

**OE SC**

Output Enable – Syndrome/Check Bits. When LOW, the 3-state output lines SC<sub>0-6</sub> are enabled. When HIGH, the SC outputs are in the high impedance state.

**ERROR**

Error Detected output. When the EDC is in Detect or Correct Mode, this output will go LOW if one or more syndrome bits are asserted, meaning there are one or more bit errors in the data or check bits. If no syndrome bits are asserted, there are no errors detected and the output will be HIGH. In Generate Mode, ERROR is forced HIGH. (In a 64-bit configuration, ERROR must be externally implemented.)

**MULTI  
ERROR**

Multiple Errors Detected output. When the EDC is in Detect or Correct Mode, this output if LOW indicates that there are two or more bit errors that have been detected. If HIGH this indicates that either one or no errors have been detected. In

**CORRECT**

Correct input. When HIGH this signal allows the correction network to correct any single-bit error in the Data Input Latch (by complementing the bit-in-error) before putting it onto the Data Output Latch. When LOW the EDC will drive data directly from the Data Input Latch to the Data Output Latch without correction.

**LE OUT**

Latch Enable – Data Output Latch. Controls the latching of the Data Output Latch. When LOW the Data Output Latch is latched to its previous state. When HIGH the Data Output Latch follows the output of the Data Input Latch as modified by the correction logic network. In Correct Mode, single-bit errors are corrected by the network before loading into the Data Output Latch. In Detect Mode, the contents of the Data Input Latch are passed through the correction network unchanged into the Data Output Latch. The inputs to the Data Output Latch are unspecified if the EDC is in Generate Mode.

**OE BYTE 0,  
OE BYTE 1**

Output Enable – Bytes 0 and 1, Data Output Latch. These lines control the 3-state outputs for each of the two bytes of the Data Output Latch. When LOW these lines enable the Data Output Latch and when HIGH these lines force the Data Output Latch into the high impedance state. The two enable lines can be separately activated to enable only one byte of the Data Output Latch at a time.

**PASS  
THRU**

Pass Thru input. This line when HIGH forces the contents of the Check Bit Input Latch onto the Syndrome/Check Bit outputs (SC<sub>0-6</sub>) and the unmodified contents of the Data Input Latch onto the inputs of the Data Output Latch.

**DIAG  
MODE<sub>0-1</sub>**

Diagnostic Mode Select. These two lines control the initialization and diagnostic operation of the EDC.

**CODE ID<sub>0-2</sub>**

Code Identification inputs. These three bits identify the size of the total data word to be processed and which 16-bit slice of larger data words a particular EDC is processing. The three allowable data word sizes are 16, 32 and 64 bits and their respective modified Hamming codes are designated 16/22, 32/39 and 64/72. Special CODE ID input 001 (ID<sub>2</sub>, ID<sub>1</sub>, ID<sub>0</sub>) is also used to instruct the EDC that the signals CODE ID<sub>0-2</sub>, DIAG MODE<sub>0-1</sub>, CORRECT and PASS THRU are to be taken from the Diagnostic Latch, rather than from the input control lines.

**LE DIAG**

Latch Enable – Diagnostic Latch. When HIGH the Diagnostic Latch follows the 16-bit data on the input lines. When LOW the outputs of the Diagnostic Latch are latched to their previous states. The Diagnostic Latch holds diagnostic check bits, and internal control signals for CODE ID<sub>0-2</sub>, DIAG MODE<sub>0-1</sub>, CORRECT and PASS THRU.



## FUNCTIONAL DESCRIPTION

The EDC contains the logic necessary to generate check bits on a 16-bit data field according to a modified Hamming code. Operating on data read from memory, the EDC will correct any single-bit error, and will detect all double and some triple-bit errors. The Am2960 may be configured to operate on 16-bit data words (with 6 check bits), 32-bit data words (with 7 check bits) and 64-bit data words (with 8 check bits). In all configurations, the device makes the error syndrome bits available on separate outputs for error data logging.

### Code and Byte Specification

The EDC may be configured in several different ways and operates differently in each configuration. It is necessary to indicate to the device what size data word is involved and which bytes of the data word it is processing. This is done with input lines CODE ID<sub>0-2</sub>, as shown in Table I. The three modified Hamming codes referred to in Table I are:

- 16/22 code – 16 data bits  
– 6 check bits  
– 22 bits in total.
- 32/39 code – 32 data bits  
– 7 check bits  
– 39 bits in total.
- 64/72 code – 64 data bits  
– 8 check bits  
– 72 bits in total.

CODE ID input 001 (ID<sub>2</sub>, ID<sub>1</sub>, ID<sub>0</sub>) is a special code used to operate the device in Internal Control Mode (described later in this section).

TABLE I. HAMMING CODE AND SLICE IDENTIFICATION.

| CODE ID <sub>2</sub> | CODE ID <sub>1</sub> | CODE ID <sub>0</sub> | Hamming Code and Slice Selected |
|----------------------|----------------------|----------------------|---------------------------------|
| 0                    | 0                    | 0                    | Code 16/22                      |
| 0                    | 0                    | 1                    | Internal Control Mode           |
| 0                    | 1                    | 0                    | Code 32/39, Bytes 0 and 1       |
| 0                    | 1                    | 1                    | Code 32/39, Bytes 2 and 3       |
| 1                    | 0                    | 0                    | Code 64/72, Bytes 0 and 1       |
| 1                    | 0                    | 1                    | Code 64/72, Bytes 2 and 3       |
| 1                    | 1                    | 0                    | Code 64/72, Bytes 4 and 5       |
| 1                    | 1                    | 1                    | Code 64/72, Bytes 6 and 7       |

### Control Mode Selection

The device control lines are GENERATE, CORRECT, PASS THRU, DIAG MODE<sub>0-1</sub> and CODE ID<sub>0-2</sub>. Table II indicates the control modes selected by various combinations of the control line inputs.

### Diagnostics

Table III shows specifically how DIAG MODE<sub>0-1</sub> select between normal operation, initialization and one of two diagnostic modes.

The Diagnostic Modes allow the user to operate the EDC under software control in order to verify proper functioning of the device.

### Check and Syndrome Bit Labeling

The check bits generated in the EDC are designated as follows:

- 16-bit configuration – CX C0, C1, C2, C4, C8;
- 32-bit configuration – CX, C0, C1, C2, C4, C8, C16;
- 64-bit configuration – CX, C0, C1, C2, C4, C8, C16, C32.

Syndrome bits are similarly labeled SX through S32. There are only 6 syndrome bits in the 16-bit configuration, 7 for 32 bits and 8 syndrome bits in the 64-bit configuration.

## FUNCTIONAL DESCRIPTION –

### 16-BIT DATA WORD CONFIGURATION

The 16-bit format consists of 16 data bits, 6 check bits and is referred to as 16/22 code (see Figure 1).

The 16-bit configuration is shown in Figure 2.

### Generate Mode

In this mode check bits will be generated that correspond to the contents of the Data Input Latch. The check bits generated are placed on the outputs SC<sub>0-5</sub> (SC<sub>6</sub> is unspecified for 16-bit operation).

Check bits are generated according to a modified Hamming code. Details of the code for check bit generation are contained in Table IV. Each check bit is generated as either an XOR or XNOR of eight of the 16 data bits as indicated in the table. The XOR function results in an even parity check bit, the XNOR is an odd parity check bit.

### Detect Mode

In this mode the device examines the contents of the Data Input Latch against the Check Bit Input Latch, and will detect all single-bit errors, all double-bit errors and some triple-bit errors. If one or more errors are detected, ERROR goes LOW. If two or more errors are detected, MULTI ERROR goes LOW. Both error indicators are HIGH if there are no errors.

Also available on device outputs SC<sub>0-5</sub> are the syndrome bits generated by the error detection step. The syndrome bits may be decoded to determine if a bit error was detected and, for single-bit errors, which of the data or check bits is in error. Table V gives the chart for decoding the syndrome bits generated by the 16-bit configuration (as an example, if the syndrome bits SX/S0/S1/S2/S4/S8 were 101001 this would be decoded to indicate that there is a single-bit error at data bit 9). If no error is detected the syndrome bits will all be zeroes.

In Detect Mode, the contents of the Data Input Latch are driven directly to the inputs of the Data Output Latch without correction.

### Correct Mode

In this mode, the EDC functions the same as in Detect Mode except that the correction network is allowed to correct (complement) any single-bit error of the Data Input Latch before putting it onto the inputs of the Data Output Latch. If multiple errors are detected, the output of the correction network is unspecified. If the single-bit error is a check bit there is no automatic correction. If check bit correction is desired, this can be done by placing the device in Generate Mode to produce a correct check bit sequence for the data in the Data Input Latch.

### Pass Thru Mode

In this mode, the unmodified contents of the Data Input Latch are placed on the inputs of the Data Output Latch and the contents of the Check Bit Input Latch are placed on outputs SC<sub>0-5</sub>.

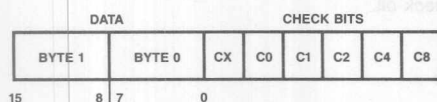


TABLE II. EDC CONTROL MODE SELECTION.

| GENERATE | CORRECT | PASS THRU | DIAG MODE <sub>0-1</sub><br>(DM <sub>1</sub> , DM <sub>0</sub> ) | CODE ID <sub>0-2</sub><br>(ID <sub>2</sub> , ID <sub>1</sub> , ID <sub>0</sub> ) | Control Mode Selected                   |
|----------|---------|-----------|--|--|---|
| LOW      | LOW     | LOW       | 00   | Not 001  | Generate                                |
| LOW      | LOW     | LOW       | 01   | Not 001  | Generate Using Diagnostic Latch         |
| LOW      | LOW     | LOW       | 10   | Not 001  | Generate                                |
| LOW      | LOW     | LOW       | 11   | Not 001  | Initialize                              |
| LOW      | LOW     | HIGH      | 00   | Not 001  | Pass Thru                               |
| LOW      | LOW     | HIGH      | 01   | Not 001  | Pass Thru                               |
| LOW      | LOW     | HIGH      | 10   | Not 001  | Pass Thru                               |
| LOW      | LOW     | HIGH      | 11   | Not 001  | Undefined                               |
| LOW      | HIGH    | LOW       | 00   | Not 001  | Generate                                |
| LOW      | HIGH    | LOW       | 01   | Not 001  | Generate Using Diagnostic Latch         |
| LOW      | HIGH    | LOW       | 10   | Not 001  | Generate                                |
| LOW      | HIGH    | LOW       | 11   | Not 001  | Initialize                              |
| LOW      | HIGH    | HIGH      | 00   | Not 001  | Pass Thru                               |
| LOW      | HIGH    | HIGH      | 01   | Not 001  | Pass Thru                               |
| LOW      | HIGH    | HIGH      | 10   | Not 001  | Pass Thru                               |
| LOW      | HIGH    | HIGH      | 11   | Not 001  | Undefined                               |
| HIGH     | LOW     | LOW       | 00   | Not 001  | Detect                                  |
| HIGH     | LOW     | LOW       | 01   | Not 001  | Detect                                  |
| HIGH     | LOW     | LOW       | 10   | Not 001  | Detect Using Diagnostic Latch           |
| HIGH     | LOW     | LOW       | 11   | Not 001  | Initialize                              |
| HIGH     | LOW     | HIGH      | 00   | Not 001  | Pass Thru                               |
| HIGH     | LOW     | HIGH      | 01   | Not 001  | Pass Thru                               |
| HIGH     | LOW     | HIGH      | 10   | Not 001  | Pass Thru                               |
| HIGH     | LOW     | HIGH      | 11   | Not 001  | Undefined                               |
| HIGH     | HIGH    | LOW       | 00   | Not 001  | Correct                                 |
| HIGH     | HIGH    | LOW       | 01   | Not 001  | Correct                                 |
| HIGH     | HIGH    | LOW       | 10   | Not 001  | Correct Using Diagnostic Latch          |
| HIGH     | HIGH    | LOW       | 11   | Not 001  | Initialize                              |
| HIGH     | HIGH    | HIGH      | 00   | Not 001  | Pass Thru                               |
| HIGH     | HIGH    | HIGH      | 01   | Not 001  | Pass Thru                               |
| HIGH     | HIGH    | HIGH      | 10   | Not 001  | Pass Thru                               |
| HIGH     | HIGH    | HIGH      | 11   | Not 001  | Undefined                               |
| Any      | Any     | Any       | Any  | 001  | Internal Control Using Diagnostic Latch |

TABLE III. DIAGNOSTIC MODE CONTROL.

| DIAG<br>MODE <sub>1</sub> | DIAG<br>MODE <sub>0</sub> | Diagnostic Mode Selected  |
|---------------------------|---------------------------|---|
| 0                         | 0                         | <b>Non-diagnostic mode.</b> The EDC functions normally in all modes.  |
| 0                         | 1                         | <b>Diagnostic Mode A.</b> The contents of the Diagnostic Latch are substituted for the normally generated check bits when in the Generate Mode. The EDC functions normally in the Detect or Correct modes.                      |
| 1                         | 0                         | <b>Diagnostic Mode B.</b> In the Detect or Correct Mode, the contents of the Diagnostic Latch are substituted for the check bits normally read from the Check Bit Input Latch. The EDC functions normally in the Generate Mode. |
| 1                         | 1                         | <b>Initialize.</b> The inputs of the Data Output Latch are forced to zeroes and the check bits generated correspond to the all-zero data.   |



Uses Modified Hamming Code 16/22

- 16 data bits
- 6 check bits
- 22 bits in total

Figure 1. 16 Bit Data Format.

MPR-730

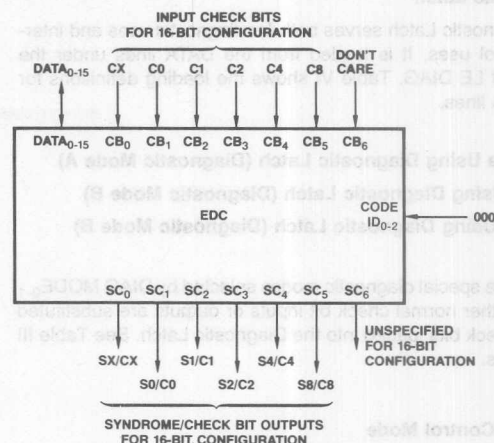


Figure 2. 16 Bit Configuration.

MPR-731

TABLE IV. 16-BIT MODIFIED HAMMING CODE – CHECK BIT ENCODE CHART.

| Generated Check Bits | Parity     | Participating Data Bits |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |
|----------------------|------------|-------------------------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|
|                      |            | 0                       | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| CX                   | Even (XOR) |                         | X | X | X |   | X |   |   | X | X |    | X  |    |    | X  |    |
| C0                   | Even (XOR) | X                       | X | X |   | X |   | X |   | X |   | X  |    | X  |    |    |    |
| C1                   | Odd (XNOR) | X                       |   |   | X | X |   |   | X |   | X | X  |    |    | X  |    | X  |
| C2                   | Odd (XNOR) | X                       | X |   |   |   | X | X | X |   |   | X  | X  | X  |    |    |    |
| C4                   | Even (XOR) |                         |   | X | X | X | X | X | X |   |   |    |    |    | X  | X  |    |
| C8                   | Even (XOR) |                         |   |   |   |   |   |   |   | X | X | X  | X  | X  | X  | X  | X  |

The check bit is generated as either an XOR or XNOR of the eight data bits noted by an "X" in the table.

TABLE V. SYNDROME DECODE TO BIT-IN-ERROR.

| Syndrome Bits | S8 | S4 | S2 |   |    |   |    |   |   |   |   |
|---------------|----|----|----|---|----|---|----|---|---|---|---|
|               | 0  | 1  | 0  | 1 | 0  | 1 | 0  | 1 | 0 | 1 | 1 |
| SX S0 S1      |    |    |    |   |    |   |    |   |   |   |   |
| 0 0 0         | *  | C8 | C4 | T | C2 | T | T  | M |   |   |   |
| 0 0 1         |    | C1 | T  | T | 15 | T | 13 | 7 | T |   |   |
| 0 1 0         |    | C0 | T  | T | M  | T | 12 | 6 | T |   |   |
| 0 1 1         |    | T  | 10 | 4 | T  | 0 | T  | T | M |   |   |
| 1 0 0         |    | CX | T  | T | 14 | T | 11 | 5 | T |   |   |
| 1 0 1         |    | T  | 9  | 3 | T  | M | T  | T | M |   |   |
| 1 1 0         |    | T  | 8  | 2 | T  | 1 | T  | T | M |   |   |
| 1 1 1         |    | M  | T  | T | M  | T | M  | M | T |   |   |

\* – no errors detected

Number – the location of the single bit-in-error

T – two errors detected

M – three or more errors detected

TABLE VI. DIAGNOSTIC LATCH LOADING – 16-BIT FORMAT.

| Data Bit | Internal Function      |
|----------|------------------------|
| 0        | Diagnostic Check Bit X |
| 1        | Diagnostic Check Bit 0 |
| 2        | Diagnostic Check Bit 1 |
| 3        | Diagnostic Check Bit 2 |
| 4        | Diagnostic Check Bit 4 |
| 5        | Diagnostic Check Bit 8 |
| 6, 7     | Don't Care             |
| 8        | CODE ID 0              |
| 9        | CODE ID 1              |
| 10       | CODE ID 2              |
| 11       | DIAG MODE 0            |
| 12       | DIAG MODE 1            |
| 13       | CORRECT                |
| 14       | PASS THRU              |
| 15       | Don't Care             |

nal control uses. It is loaded from the DATA lines under the control of LE DIAG. Table VI shows the loading definitions for the DATA lines.

#### Generate Using Diagnostic Latch (Diagnostic Mode A)

#### Detect Using Diagnostic Latch (Diagnostic Mode B)

#### Correct Using Diagnostic Latch (Diagnostic Mode B)

These are special diagnostic modes selected by DIAG MODE<sub>0-1</sub> where either normal check bit inputs or outputs are substituted for by check bits loaded into the Diagnostic Latch. See Table III for details.

#### Internal Control Mode

This mode is selected by CODE ID<sub>0-2</sub> input 001 (ID<sub>2</sub>, ID<sub>1</sub>, ID<sub>0</sub>).

When in Internal Control Mode, the EDC takes the CODE ID<sub>0-2</sub>, DIAG MODE<sub>0-1</sub>, CORRECT and PASS THRU control signals from the internal Diagnostic Latch rather than from the external input lines.

Table VI gives the format for loading the Diagnostic Latch.

### FUNCTIONAL DESCRIPTION — 32-BIT DATA WORD CONFIGURATION

The 32-bit format consists of 32 data bits, 7 check bits and is referred to as 32/39 code (see Figure 3).

The 32-bit configuration is shown in Figure 4.

The upper EDC (Slice 0/1) handles the least significant bytes 0 and 1 — the external DATA lines 0 to 15 are connected to the same numbered inputs of the upper device. The lower EDC (Slice 2/3) handles the most significant bytes 2 and 3 — the external DATA lines for bits 16 to 31 are connected to inputs DATA<sub>0</sub> through DATA<sub>15</sub> respectively.

The valid syndrome and check bit outputs are those of Slice 2/3 as shown in the diagram. In Correct Mode these must be read into Slice 0/1 via the CB inputs, thus requiring external buffering and output enabling of the check bit lines as shown. The  $\overline{OE}$  SC signal can be used to control enabling of check bit inputs — when syndrome outputs are enabled, the external check bit inputs will be disabled.

The valid  $\overline{ERROR}$  and  $\overline{MULTI ERROR}$  outputs are those of the Slice 2/3. The  $\overline{ERROR}$  and  $\overline{MULTI ERROR}$  outputs of Slice 0/1 are unspecified. All of the latch enables and control signals must be input to both of the devices.

#### Generate Mode

In this mode check bits will be generated that correspond to the contents of the Data Input Latch. The check bits generated are placed on the outputs SC<sub>0-6</sub> of Slice 2/3.

XNOR or 16 of the 32 data bits as indicated in the table. The XOR function results in an even parity check bit, the XNOR in an odd parity check bit.

#### Detect Mode

In this mode the device examines the contents of the Data Input Latch against the Check Bit Input Latch, and will detect all single-bit errors, all double-bit errors and some triple-bit errors. If one or more errors are detected,  $\overline{ERROR}$  goes LOW. If two or more errors are detected,  $\overline{MULTI ERROR}$  goes LOW. Both error indicators are HIGH if there are no errors. The valid  $\overline{ERROR}$  and  $\overline{MULTI ERROR}$  signals are those of Slice 2/3 — those of Slice 0/1 are undefined.

Also available on Slice 2/3 outputs SC<sub>0-6</sub> are the syndrome bits generated by the error detection step. The syndrome bits may be decoded to determine if a bit error was detected and, for single-bit errors, which of the data or check bits is in error. Table VIII gives the chart for decoding the syndrome bits generated for the 32-bit configuration (as an example, if the syndrome bits SX/S0/S1/S2/S4/S8/S16 were 0010011 this would be decoded to indicate that there is a single-bit error at data bit 25). If no error is detected the syndrome bits will be all zeroes.

In Detect Mode, the contents of the Data Input Latch are driven directly to the inputs of the Data Output Latch without corrections.

#### Correct Mode

In this mode, the EDC functions the same as in Detect Mode except that the correction network is allowed to correct (complement) any single-bit error of the Data Input Latch before putting it onto the inputs of the Data Output Latch. If multiple errors are detected, the output of the correction network is unspecified. If the single-bit error is a check bit there is no automatic correction — if desired this would be done by placing the device in Generate Mode to produce a correct check bit sequence for the data in the Data Input Latch.

For data correction, both Slices 0/1 and 2/3 require access to the syndrome bits on Slice 2/3's outputs SC<sub>0-6</sub>. Slice 2/3 has access to these syndrome bits through internal data paths, but for Slice 0/1 they must be read through the inputs CB<sub>0-6</sub>. The device connections for this are shown in Figure 4. When in Correct Mode the SC outputs must be enabled so that they are available for reading in through the CB inputs.

#### Pass Thru Mode

In this mode, the unmodified contents of the Data Input Latch are placed on the inputs of the Data Output Latch and the contents of the Check Bit Input Latch are placed on outputs SC<sub>0-6</sub> of Slice 2/3.

Uses Modified Hamming Code 32/39

- 32 data bits
- 7 check bits
- 39 bits in total

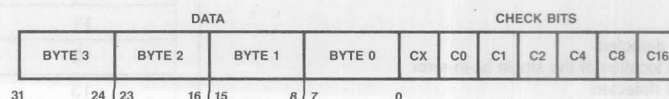


Figure 3. 32 Bit Data Format.





TABLE VIII. SYNDROME DECODE TO BIT-IN-ERROR.

| Syndrome Bits |    |    |    | S16 | S8 | S4  | 0  | 1  | 0  | 1 | 0  | 1  | 0 | 1  |
|---------------|----|----|----|-----|----|-----|----|----|----|---|----|----|---|----|
| SX            | S0 | S1 | S2 |     |    |     |    |    |    |   |    |    |   |    |
| 0             | 0  | 0  | 0  |     | *  | C16 | C8 | T  | C4 | T | T  |    |   | 30 |
| 0             | 0  | 0  | 1  |     | C2 | T   | T  | 27 | T  | 5 | M  | T  |   |    |
| 0             | 0  | 1  | 0  |     | C1 | T   | T  | 25 | T  | 3 | 15 | T  |   |    |
| 0             | 0  | 1  | 1  |     | T  | M   | 13 | T  | 23 | T | T  | M  |   |    |
| 0             | 1  | 0  | 0  |     | C0 | T   | T  | 24 | T  | 2 | M  | T  |   |    |
| 0             | 1  | 0  | 1  |     | T  | 1   | 12 | T  | 22 | T | T  | M  |   |    |
| 0             | 1  | 1  | 0  |     | T  | M   | 10 | T  | 20 | T | T  | M  |   |    |
| 0             | 1  | 1  | 1  |     | 16 | T   | T  | M  | T  | M | M  | T  |   |    |
| 1             | 0  | 0  | 0  |     | CX | T   | T  | M  | T  | M | 14 | T  |   |    |
| 1             | 0  | 0  | 1  |     | T  | M   | 11 | T  | 21 | T | T  | M  |   |    |
| 1             | 0  | 1  | 0  |     | T  | M   | 9  | T  | 19 | T | T  | 31 |   |    |
| 1             | 0  | 1  | 1  |     | M  | T   | T  | 29 | T  | 7 | M  | T  |   |    |
| 1             | 1  | 0  | 0  |     | T  | M   | 8  | T  | 18 | T | T  | M  |   |    |
| 1             | 1  | 0  | 1  |     | 17 | T   | T  | 28 | T  | 6 | M  | T  |   |    |
| 1             | 1  | 1  | 0  |     | M  | T   | T  | 26 | T  | 4 | M  | T  |   |    |
| 1             | 1  | 1  | 1  |     | T  | 0   | M  | T  | M  | T | T  | M  |   |    |

\* – no errors detected

Numbers – number of the single bit-in-error

T – two errors detected

M – three or more errors detected

**Diagnostic Latch**

The Diagnostic Latch serves both for diagnostic uses and internal control uses. It is loaded from the DATA lines under the control of LE DIAG. Table IX shows the loading definitions for the DATA lines.

**Generate Using Diagnostic Latch (Diagnostic Mode A)****Detect Using Diagnostic Latch (Diagnostic Mode B)****Correct Using Diagnostic Latch (Diagnostic Mode B)**

These are special diagnostic modes selected by DIAG MODE<sub>0-1</sub> where either normal check bit inputs or outputs are substituted for by check bits from the Diagnostic Latch. See Table III for details.

**Internal Control Mode**

This mode is selected by CODE ID<sub>0-2</sub>, input 001 (ID<sub>2</sub>, ID<sub>1</sub>, ID<sub>0</sub>).

When in Internal Control Mode the device takes the CODE ID<sub>0-2</sub>, DIAG MODE<sub>0-1</sub>, CORRECT and PASS THRU signals

from the internal Diagnostic Latch rather than from the external control lines.

Table IX gives the format for loading the Diagnostic Latch.

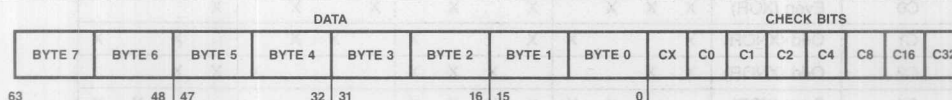
**FUNCTIONAL DESCRIPTION –  
64-BIT DATA WORD CONFIGURATION**

The 64-bit format consists of 64 data bits, 8 check bits and is referred to as 64/72 code (see Figure 5).

The configuration to process 64-bit format is shown in Figure 6. In this configuration a portion of the syndrome generation and error detection is implemented externally of the EDCs in MSI. For error correction the syndrome bits generated must be read back into all four EDCs through the CB inputs. This necessitates the check bit buffering shown in the connection diagram of Figure 6. The OE SC signal can control the check bit enabling – when syndrome bit outputs are enabled the external check bit lines will be disabled so that the syndrome bits may be read onto the CB inputs.

TABLE IX. DIAGNOSTIC LATCH LOADING –  
32-BIT FORMAT.

| Data Bit | Internal Function       |
|----------|-------------------------|
| 0        | Diagnostic Check Bit X  |
| 1        | Diagnostic Check Bit 0  |
| 2        | Diagnostic Check Bit 1  |
| 3        | Diagnostic Check Bit 2  |
| 4        | Diagnostic Check Bit 4  |
| 5        | Diagnostic Check Bit 8  |
| 6        | Diagnostic Check Bit 16 |
| 7        | Don't Care              |
| 8        | Slice 0/1 – CODE ID 0   |
| 9        | Slice 0/1 – CODE ID 1   |
| 10       | Slice 0/1 – CODE ID 2   |
| 11       | Slice 0/1 – DIAG MODE 0 |
| 12       | Slice 0/1 – DIAG MODE 1 |
| 13       | Slice 0/1 – CORRECT     |
| 14       | Slice 0/1 – PASS THRU   |
| 15       | Don't Care              |
| 16-23    | Don't Care              |
| 24       | Slice 2/3 – CODE ID 0   |
| 25       | Slice 2/3 – CODE ID 1   |
| 26       | Slice 2/3 – CODE ID 2   |
| 27       | Slice 2/3 – DIAG MODE 0 |
| 28       | Slice 2/3 – DIAG MODE 1 |
| 29       | Slice 2/3 – CORRECT     |
| 30       | Slice 2/3 – PASS THRU   |
| 31       | Don't Care              |



Uses Modified Hamming Code 64/72

– 64 data bits

– 8 check bits

– 72 bits in total

Figure 5. 64 Bit Data Format.



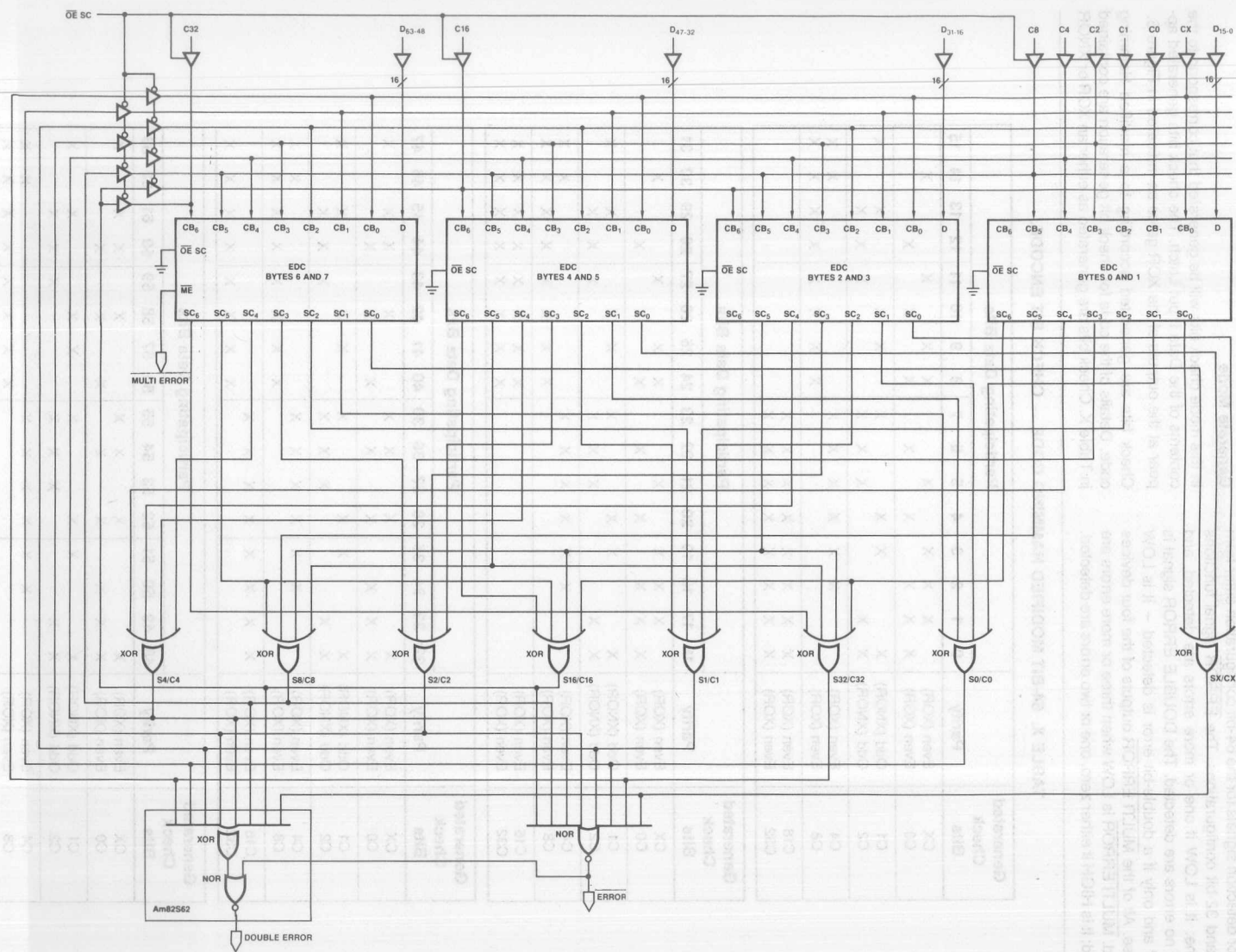


Figure 6. Am2960 - 64 Bit Data Configuration.

Input CB<sub>6</sub> of Slice 0/1 is unused and need not be connected. Output SC<sub>6</sub> of Slice 2/3 is unspecified for the 64-bit configuration.

The error detection signals for the 64-bit configuration differ from the 16 and 32-bit configurations. The ERROR signal functions the same: it is LOW if one or more errors are detected, and HIGH if no errors are detected. The DOUBLE ERROR signal is HIGH if and only if a double-bit error is detected – it is LOW otherwise. All of the MULTI ERROR outputs of the four devices are valid. MULTI ERROR is LOW when three or more errors are detected; it is HIGH if either zero, one or two errors are detected.

This is a different meaning for MULTI ERROR than in other configurations.

#### Generate Mode

In this mode check bits will be generated that correspond to the contents of the Data Input Latch. The check bits generated appear at the outputs of the XOR gates as indicated in Figure 6.

Check bits are generated according to a modified Hamming code. Details of the code for check bit generation are contained in Table X. Check bits are generated as either an XOR or XNOR

TABLE X. 64-BIT MODIFIED HAMMING CODE – CHECK BIT ENCODE.

| Generated Check Bits | Parity     | Participating Data Bits |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |
|----------------------|------------|-------------------------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|
|                      |            | 0                       | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| CX                   | Even (XOR) |                         | X | X | X |   | X |   |   | X | X |    | X  |    |    |    | X  |
| C0                   | Even (XOR) | X                       | X | X |   | X |   | X |   | X |   | X  |    | X  |    |    |    |
| C1                   | Odd (XNOR) | X                       |   |   | X | X |   |   | X |   | X | X  |    |    | X  |    | X  |
| C2                   | Odd (XNOR) | X                       | X |   |   |   | X | X | X |   |   |    | X  | X  | X  |    |    |
| C4                   | Even (XOR) |                         |   | X | X | X | X | X | X |   |   |    |    |    |    | X  | X  |
| C8                   | Even (XOR) |                         |   |   |   |   |   |   |   | X | X | X  | X  | X  | X  | X  | X  |
| C16                  | Even (XOR) | X                       | X | X | X | X | X | X | X |   |   |    |    |    |    |    |    |
| C32                  | Even (XOR) | X                       | X | X | X | X | X | X | X |   |   |    |    |    |    |    |    |

| Generated Check Bits | Parity     | Participating Data Bits |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
|----------------------|------------|-------------------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
|                      |            | 16                      | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| CX                   | Even (XOR) |                         | X  | X  | X  |    | X  |    |    | X  | X  |    | X  |    |    |    | X  |
| C0                   | Even (XOR) | X                       | X  | X  |    | X  |    | X  |    | X  |    | X  |    | X  |    |    |    |
| C1                   | Odd (XNOR) | X                       |    |    | X  | X  |    |    | X  |    | X  | X  |    |    | X  |    | X  |
| C2                   | Odd (XNOR) | X                       | X  |    |    |    | X  | X  | X  |    |    |    | X  | X  | X  |    |    |
| C4                   | Even (XOR) |                         |    | X  | X  | X  | X  | X  | X  |    |    |    |    |    |    | X  | X  |
| C8                   | Even (XOR) |                         |    |    |    |    |    |    |    | X  | X  | X  | X  | X  | X  | X  | X  |
| C16                  | Even (XOR) |                         |    |    |    |    |    |    |    | X  | X  | X  | X  | X  | X  | X  | X  |
| C32                  | Even (XOR) |                         |    |    |    |    |    |    |    | X  | X  | X  | X  | X  | X  | X  | X  |

| Generated Check Bits | Parity     | Participating Data Bits |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
|----------------------|------------|-------------------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
|                      |            | 32                      | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 |
| CX                   | Even (XOR) | X                       |    |    |    | X  |    | X  | X  |    |    | X  |    | X  | X  |    | X  |
| C0                   | Even (XOR) | X                       | X  | X  |    | X  |    | X  |    | X  |    | X  |    | X  |    |    |    |
| C1                   | Odd (XNOR) | X                       |    |    | X  | X  |    |    | X  |    | X  | X  |    |    | X  |    | X  |
| C2                   | Odd (XNOR) | X                       | X  |    |    |    | X  | X  | X  |    |    |    | X  | X  | X  |    |    |
| C4                   | Even (XOR) |                         |    | X  | X  | X  | X  | X  | X  |    |    |    |    |    |    | X  | X  |
| C8                   | Even (XOR) |                         |    |    |    |    |    |    |    | X  | X  | X  | X  | X  | X  | X  | X  |
| C16                  | Even (XOR) | X                       | X  | X  | X  | X  | X  | X  | X  |    |    |    |    |    |    |    |    |
| C32                  | Even (XOR) | X                       | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  |

| Generated Check Bits | Parity     | Participating Data Bits |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
|----------------------|------------|-------------------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
|                      |            | 48                      | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 |
| CX                   | Even (XOR) | X                       |    |    |    | X  |    | X  | X  |    |    | X  |    | X  | X  |    | X  |
| C0                   | Even (XOR) | X                       | X  | X  |    | X  |    | X  |    | X  |    | X  |    | X  |    |    |    |
| C1                   | Odd (XNOR) | X                       |    |    | X  | X  |    |    | X  |    | X  | X  |    |    | X  |    | X  |
| C2                   | Odd (XNOR) | X                       | X  |    |    |    | X  | X  | X  |    |    |    | X  | X  | X  |    |    |
| C4                   | Even (XOR) |                         |    | X  | X  | X  | X  | X  | X  |    |    |    |    |    |    | X  | X  |
| C8                   | Even (XOR) |                         |    |    |    |    |    |    |    | X  | X  | X  | X  | X  | X  | X  | X  |
| C16                  | Even (XOR) |                         |    |    |    |    |    |    |    | X  | X  | X  | X  | X  | X  | X  | X  |
| C32                  | Even (XOR) | X                       | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  | X  |

The check bit is generated as either an XOR or XNOR of the 32 data bits noted by an "X" in the table.

of 32 of the 64 bits as indicated in the table. The XOR function results in an even parity check bit, the XNOR in an odd parity check bit.

### Detect Mode

In this mode the device examines the contents of the Data Input Latch against the Check Bit Input Latch, and will detect all single-bit errors, all double-bit errors and some triple-bit errors. If one or more errors are detected, ERROR goes LOW. If exactly two errors are detected, DOUBLE ERROR goes HIGH. If three or more errors are detected, MULTI ERROR goes LOW – the MULTI ERROR output of any of the four EDCs may be used.

Available as XOR gate outputs are the generated syndrome bits (see Figure 6). The syndrome bits may be decoded to determine if a bit error was detected and, for single-bit errors, which of the data or check bits is in error. Table XI gives the chart for encoding the syndrome bits generated for the 64-bit configuration (as an example, if the syndrome bits SX/S0/S1/S2/S4/S8/S16/S32 were 00100101 this would be decoded to indicate that there is a single-bit error at data bit 41). If no error is detected the syndrome bits will all be zeroes.

In Detect Mode the contents of the Data Input Latch are driven directly to the inputs of the Data Output Latch without corrections.

### Correct Mode

In this mode, the EDC functions the same as in Detect Mode except that the correction network is allowed to correct (complement) any single-bit error of the Data Input Latch before putting it onto the inputs of the Data Output Latch. If multiple errors are detected, the output of the correction network is unspecified. If the single bit error is a check bit there is no automatic correction. Check bit correction can be done by placing the device in generate mode to produce a correct check bit sequence for the data in the Data Input Latch.

To perform the correction step, all four slices require access to the syndrome bits which are generated externally of the devices. This access is provided by reading the syndrome bits in through the CB inputs. The device connections for this are shown in Figure 6. When in Correct Mode the SC outputs must be enabled so that the syndrome bits are available at the CB inputs.

### Pass Thru Mode

In this mode, the unmodified contents of the Data Input Latch are placed on the inputs of the Data Output Latch, and the contents of the Check Bit Input Latch are passed through the external XOR network and appear unmodified at the XOR gate outputs labeled CX to C32 (see Figure 6).

TABLE XI. SYNDROME DECODE TO BIT-IN-ERROR.

| Syndrome Bits |    |    |    | S32 | S16 | S8  | S4 |    |    |    |    |    |    |    |   |    |    |    |    |  |  |  |  |  |  |  |  |  |  |
|---------------|----|----|----|-----|-----|-----|----|----|----|----|----|----|----|----|---|----|----|----|----|--|--|--|--|--|--|--|--|--|--|
| SX            | S0 | S1 | S2 |     |     |     |    |    |    |    |    |    |    |    |   |    |    |    |    |  |  |  |  |  |  |  |  |  |  |
| 0             | 0  | 0  | 0  | *   | C32 | C16 | T  | C8 | T  | T  | M  | C4 | T  | T  | M | T  | 46 | 62 | T  |  |  |  |  |  |  |  |  |  |  |
| 0             | 0  | 0  | 1  | C2  | T   | T   | M  | T  | 43 | 59 | T  | T  | 53 | 37 | T | M  | T  | T  | M  |  |  |  |  |  |  |  |  |  |  |
| 0             | 0  | 1  | 0  | C1  | T   | T   | M  | T  | 41 | 57 | T  | T  | 51 | 35 | T | 15 | T  | T  | 31 |  |  |  |  |  |  |  |  |  |  |
| 0             | 0  | 1  | 1  | T   | M   | M   | T  | 13 | T  | T  | 29 | 23 | T  | T  | 7 | T  | M  | M  | T  |  |  |  |  |  |  |  |  |  |  |
| 0             | 1  | 0  | 0  | C0  | T   | T   | M  | T  | 40 | 56 | T  | T  | 50 | 34 | T | M  | T  | T  | M  |  |  |  |  |  |  |  |  |  |  |
| 0             | 1  | 0  | 1  | T   | 49  | 33  | T  | 12 | T  | T  | 28 | 22 | T  | T  | 6 | T  | M  | M  | T  |  |  |  |  |  |  |  |  |  |  |
| 0             | 1  | 1  | 0  | T   | M   | M   | T  | 10 | T  | T  | 26 | 20 | T  | T  | 4 | T  | M  | M  | T  |  |  |  |  |  |  |  |  |  |  |
| 0             | 1  | 1  | 1  | 16  | T   | T   | 0  | T  | M  | M  | T  | T  | M  | M  | T | M  | T  | T  | M  |  |  |  |  |  |  |  |  |  |  |
| 1             | 0  | 0  | 0  | CX  | T   | T   | M  | T  | M  | M  | T  | T  | M  | M  | T | 14 | T  | T  | 30 |  |  |  |  |  |  |  |  |  |  |
| 1             | 0  | 0  | 1  | T   | M   | M   | T  | 11 | T  | T  | 27 | 21 | T  | T  | 5 | T  | M  | M  | T  |  |  |  |  |  |  |  |  |  |  |
| 1             | 0  | 1  | 0  | T   | M   | M   | T  | 9  | T  | T  | 25 | 19 | T  | T  | 3 | T  | 47 | 63 | T  |  |  |  |  |  |  |  |  |  |  |
| 1             | 0  | 1  | 1  | M   | T   | T   | M  | T  | 45 | 61 | T  | T  | 55 | 39 | T | M  | T  | T  | M  |  |  |  |  |  |  |  |  |  |  |
| 1             | 1  | 0  | 0  | T   | M   | M   | T  | 8  | T  | T  | 24 | 18 | T  | T  | 2 | T  | M  | M  | T  |  |  |  |  |  |  |  |  |  |  |
| 1             | 1  | 0  | 1  | 17  | T   | T   | 1  | T  | 44 | 60 | T  | T  | 54 | 38 | T | M  | T  | T  | M  |  |  |  |  |  |  |  |  |  |  |
| 1             | 1  | 1  | 0  | M   | T   | T   | M  | T  | 42 | 58 | T  | T  | 52 | 36 | T | M  | T  | T  | M  |  |  |  |  |  |  |  |  |  |  |
| 1             | 1  | 1  | 1  | T   | 48  | 32  | T  | M  | T  | T  | M  | M  | T  | T  | M | T  | M  | M  | T  |  |  |  |  |  |  |  |  |  |  |

\* – no errors detected

Number – the number of the single bit-in-error

T – two errors detected

M – more than two errors detected

**Diagnostic Latch**

The Diagnostic Latch serves both for diagnostic uses and internal control uses. It is loaded from the DATA lines under the control of LE DIAG. Table XII shows the loading definitions for the DATA lines.

**Generate Using Diagnostic Latch (Diagnostic Mode A)****Detect Using Diagnostic Latch (Diagnostic Mode B)****Correct Using Diagnostic Latch (Diagnostic Mode B)**

These are special diagnostic modes selected by DIAG MODE<sub>0-1</sub> where either normal check bit inputs or outputs are substituted for by check bits from the Diagnostic Latch. See Table III for details.

**Internal Control Mode**

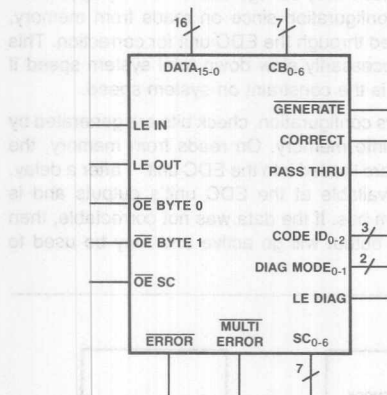
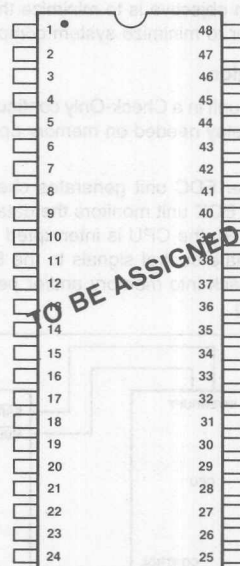
This mode is selected by CODE ID<sub>0-2</sub>, input 001 (ID<sub>2</sub>, ID<sub>1</sub>, ID<sub>0</sub>).

When in Internal Control Mode the EDC takes the CODE ID<sub>0-2</sub>, DIAG MODE<sub>0-1</sub>, CORRECT and PASS THRU signals from the internal Diagnostic Latch rather than from the external control lines. Table XII gives format for loading the Diagnostic Latch.

**TABLE XII. DIAGNOSTIC LATCH LOADING – 64-BIT FORMAT.**

| Data Bit | Internal Function       | Data Bit | Internal Function       |
|----------|-------------------------|----------|-------------------------|
| 0        | Diagnostic Check Bit X  | 31       | Don't Care              |
| 1        | Diagnostic Check Bit 0  | 32-37    | Don't Care              |
| 2        | Diagnostic Check Bit 1  | 38       | Diagnostic Check Bit 16 |
| 3        | Diagnostic Check Bit 2  | 39       | Don't Care              |
| 4        | Diagnostic Check Bit 4  | 40       | Slice 4/5 – CODE ID 0   |
| 5        | Diagnostic Check Bit 8  | 41       | Slice 4/5 – CODE ID 1   |
| 6, 7     | Don't Care              | 42       | Slice 4/5 – CODE ID 2   |
| 8        | Slice 0/1 – CODE ID 0   | 43       | Slice 4/5 – DIAG MODE 0 |
| 9        | Slice 0/1 – CODE ID 1   | 44       | Slice 4/5 – DIAG MODE 1 |
| 10       | Slice 0/1 – CODE ID 2   | 45       | Slice 4/5 – CORRECT     |
| 11       | Slice 0/1 – DIAG MODE 0 | 46       | Slice 4/5 – PASS THRU   |
| 12       | Slice 0/1 – DIAG MODE 1 | 47       | Don't Care              |
| 13       | Slice 0/1 – CORRECT     | 48-54    | Don't Care              |
| 14       | Slice 0/1 – PASS THRU   | 55       | Diagnostic Check Bit 32 |
| 15       | Don't Care              | 56       | Slice 6/7 – CODE ID 0   |
| 16-23    | Don't Care              | 57       | Slice 6/7 – CODE ID 1   |
| 24       | Slice 2/3 – CODE ID 0   | 58       | Slice 6/7 – CODE ID 2   |
| 25       | Slice 2/3 – CODE ID 1   | 59       | Slice 6/7 – DIAG MODE 0 |
| 26       | Slice 2/3 – CODE ID 2   | 60       | Slice 6/7 – DIAG MODE 1 |
| 27       | Slice 2/3 – DIAG MODE 0 | 61       | Slice 6/7 – CORRECT     |
| 28       | Slice 2/3 – DIAG MODE 1 | 62       | Slice 6/7 – PASS THRU   |
| 29       | Slice 2/3 – CORRECT     | 63       | Don't Care              |
| 30       | Slice 2/3 – PASS THRU   |          |                         |

## LOGIC SYMBOL

CONNECTION DIAGRAM  
Top View

2

Note: Pin 1 is marked for orientation.

MPR-736

MPR-737



## APPLICATIONS

The EDC unit may be used in two different ways depending upon whether the design objective is to minimize the total time for memory operations or to minimize system complexity.

## Check-Only Configuration

Figure 7 shows the EDC unit in a Check-Only configuration. This method minimizes the delay needed on memory operations for EDC.

On writes to memory the EDC unit generates check-bits. On reads from memory, the EDC unit monitors the data and check bits. If an error is detected, the CPU is interrupted – the CPU then issues the appropriate control signals to the EDC unit to correct the data, write back into memory and/or perform diagnostics and error logging.

## Correct-Always Configuration

Figure 8 illustrates the use of EDC unit in a Correct-Always configuration. This method has the advantage of being less complex than the Check-Only configuration. Memory operations are slower in this configuration since on reads from memory, data is always passed through the EDC unit for correction. This method does not necessarily slow down total system speed if the CPU cycle-time is the constraint on system speed.

In the Correct-Always configuration, check bits are generated by the EDC on writes into memory. On reads from memory, the check and data bits are loaded into the EDC unit – after a delay, corrected data is available at the EDC unit's outputs and is placed on the system bus. If the data was not correctable, then the MULTI ERROR output will go active and may be used to interrupt the CPU.

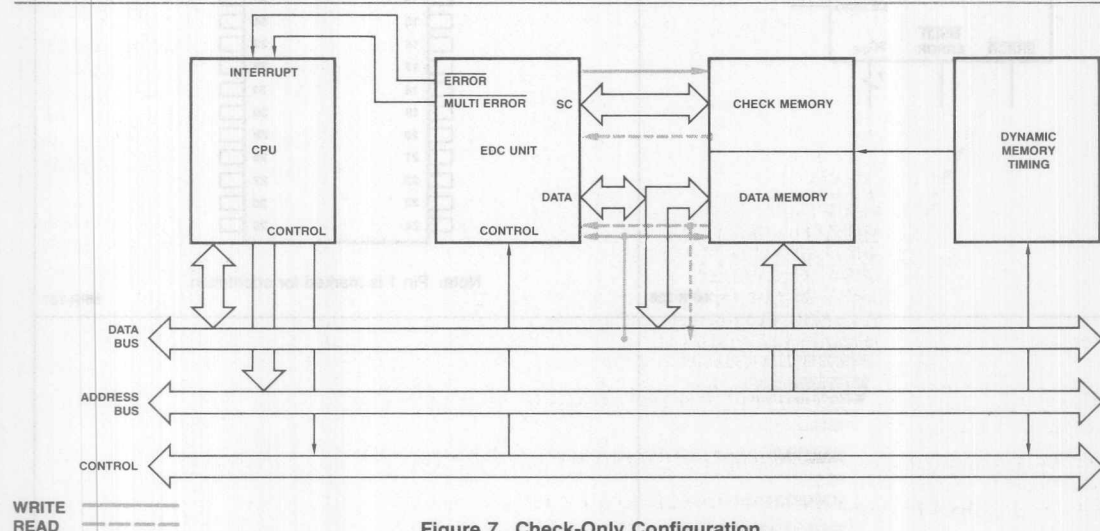


Figure 7. Check-Only Configuration.

MPR-738

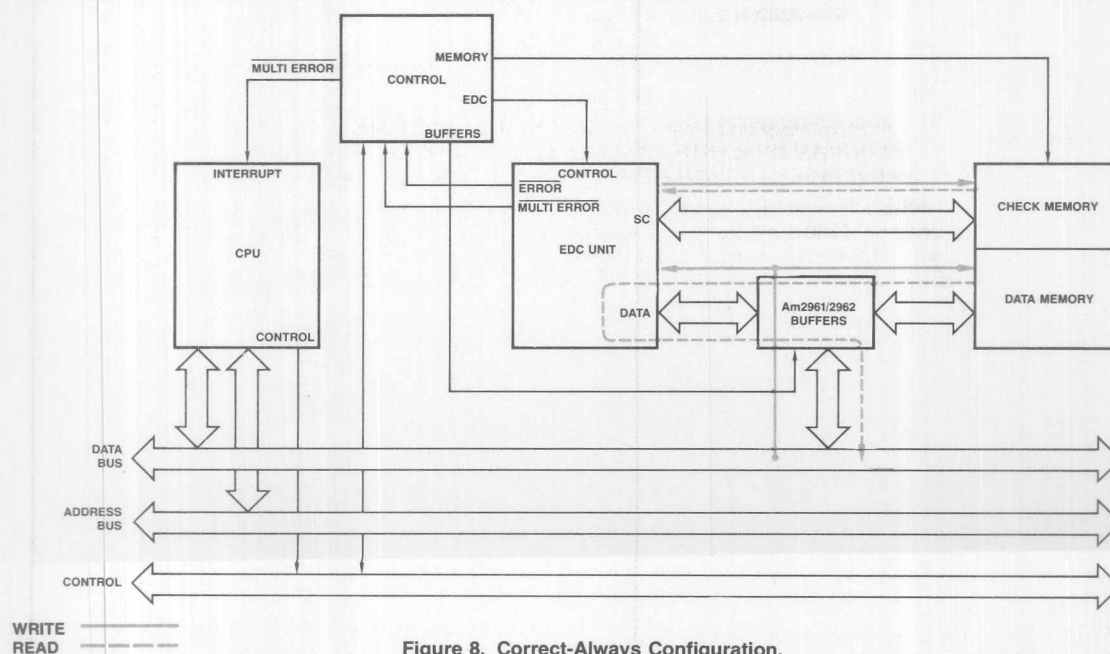


Figure 8. Correct-Always Configuration.

MPR-739

Data latches between the error correction data bus and the system data bus facilitate byte writing in memory systems wider than 8-bits. They also provide a data holding capability during single-step system operation.

## BLI-121

BLI-122

2-329

# Am2964

## Dynamic Memory Controller

IN DEVELOPMENT

### DISTINCTIVE CHARACTERISTICS

- Dynamic Memory Controller for 16K and 64K MOS dynamic RAMs
- 8-Bit Refresh Counter for refresh address generation, has clear input and terminal count output
- Refresh Counter terminal count selectable at 256 or 128
- Latch Input  $\overline{\text{RAS}}$  Decoder provides 4  $\overline{\text{RAS}}$  outputs, all active during refresh
- Dual 8-Bit Address Latches plus separate  $\overline{\text{RAS}}$  Decoder Latches
- Grouping functions on a common chip minimizes speed differential/skew between address,  $\overline{\text{RAS}}$  and  $\overline{\text{CAS}}$  outputs
- 3-Port, 8-Bit Address Multiplexer with Schottky speed
- Burst mode, distributed refresh or transparent refresh mode determined by user
- Non-inverting address,  $\overline{\text{RAS}}$  and  $\overline{\text{CAS}}$  paths
- 100% product assurance screening to MIL-STD-883 requirements

### FUNCTIONAL DESCRIPTION

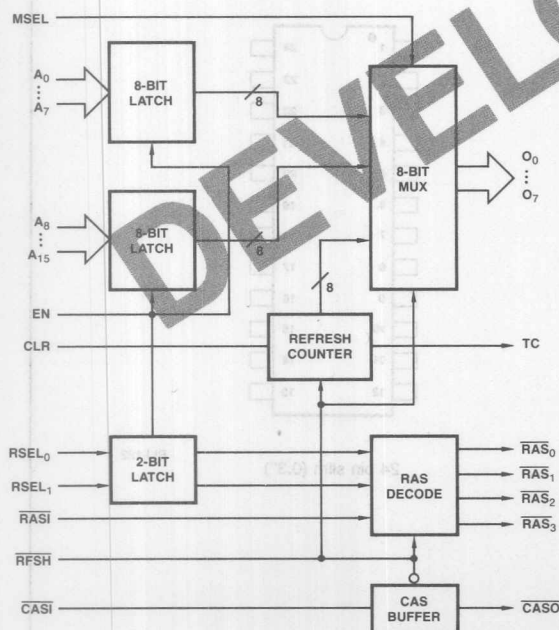
The Am2964 Dynamic Memory Controller replaces several MSI devices by grouping several unique functions. Two 8-bit latches capture and hold the memory address. These latches and a clearable, 8-bit refresh counter feed into an 8-bit, 3-input, Schottky speed MUX, for output to the dynamic RAM address lines.

The same silicon chip also includes a special  $\overline{\text{RAS}}$  decoder and  $\overline{\text{CAS}}$  buffer. Placing these functions on the same chip minimizes the time skew between output functions which would otherwise be separate MSI chips, and therefore, allows a faster memory cycle time by the amount of skew eliminated.

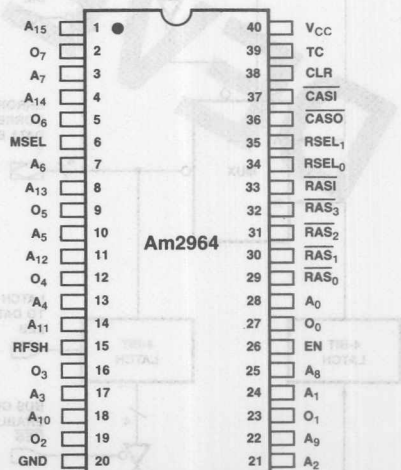
Pulsing the active LOW refresh line  $\overline{\text{RFSH}}$ , switches the MUX to the counter output, inhibits  $\overline{\text{CAS}}$ , and forces all four  $\overline{\text{RAS}}$  decoder outputs active simultaneously. The counter is advanced at the end of the refresh cycle – the LOW-to-HIGH transition of  $\overline{\text{RFSH}}$ . Various refresh modes can be accommodated – for 16K or 64K RAMs and for a wide variety of processor configurations.

$\text{A}_{15}$  is a dual function input which controls the refresh counter's range. For 64K RAMs it is an address input. For 16K RAMs it can be pulled to +12V through 1K $\Omega$  to terminate the refresh count at 128 instead of 256.

### LOGIC DIAGRAM



### CONNECTION DIAGRAM Top View



Note: Pin 1 is marked for orientation.

BLI-123

BLI-124

# Am2965 • Am2966

## Octal Dynamic Memory Drivers with Three-State Outputs

### DISTINCTIVE CHARACTERISTICS

- Octal drivers for 16K and 64K Dynamic RAMs
- Maximum performance with  $-0.5V$  max undershoot
- No external resistors required
- Improved performance over 'S240/'S244
- $t_{PD}$  specified for 50pF and 500pF
- Specified for  $V_{CC} = 5.0V \pm 10\%$  for COM'L and MIL versions
- $V_{OH}$  guaranteed at  $V_{CC} - 1.15V$  min
- $I_{OH}$  and  $I_{OL}$  specified at  $+2.0V$
- Low-power Schottky input characteristics
- Inverting Am2965 and non-inverting Am2966
- Glitch-free 3-state outputs during power-up/down
- Pin compatible replacements for designs using 'S240 and 'S244 plus external resistors
- Symmetrical controlled rise and fall time
- 100% product assurance screening per MIL-STD-883

### CONNECTION DIAGRAM Top View



Note: Pin 1 is marked for orientation.

BLI-125

### FUNCTIONAL DESCRIPTION

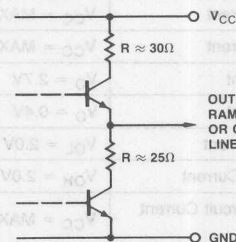
The Am2965 and Am2966 are designed and specified to drive the capacitive input characteristics of the address and control lines of MOS dynamic RAMs. The unique design of the lower output driver includes a collector resistor to control undershoot on the HIGH-to-LOW transition. The upper output driver pulls up to  $V_{CC} - 1.15V$  to be compatible with MOS memory and is designed to have a rise time symmetrical with the lower output's controlled fall time. This allows optimization of Dynamic RAM performance.

The Am2965 and Am2966 are pin-compatible with the popular 'S240 and 'S244 with identical 3-state output enable controls. The Am2965 has inverting drivers and the Am2966 has non-inverting drivers.

The inclusion of an internal resistor in the lower output driver eliminates the requirement for an external series resistor, therefore reducing package count and the board area required. The internal resistor controls the output fall and undershoot without slowing the output rise.

These devices are designed for use with the Am2964 Dynamic Memory Controller where large dynamic memories with highly capacitive input lines require additional buffering. Driving eight address lines or four  $\overline{RAS}$  and four  $\overline{CAS}$  lines with drivers on the same silicon chip also provides a significant performance advantage by minimizing skew between drivers. Each device has specified skew between drivers to improve the memory access worst case timing over the min and max  $t_{PD}$  difference of unspecified devices.

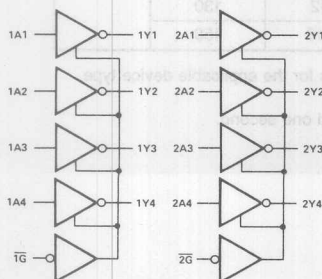
### TYPICAL OUTPUT DRIVER



BLI-126

### LOGIC DIAGRAMS

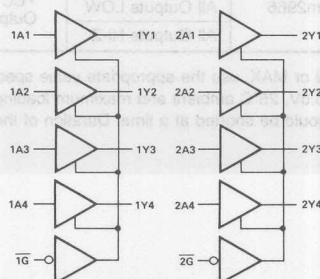
#### Am2965



BLI-127

| Inputs         |   | Outputs |
|----------------|---|---------|
| $\overline{G}$ | A | Y       |
| H              | X | Z       |
| L              | H | L       |
| L              | L | H       |

#### Am2966



BLI-128

| Inputs         |   | Outputs |
|----------------|---|---------|
| $\overline{G}$ | A | Y       |
| H              | X | Z       |
| L              | L | L       |
| L              | H | H       |



|   |               |
|---|---------------|
| Temperature (Ambient) Under Bias                    | -65 to +150°C |
| Supply Voltage to Ground Potential Continuous       | -55 to +125°C |
| DC Voltage Applied to Outputs for High Output State | -0.5 to +7.0V |
| DC Input Voltage                                    | -0.5 to +7.0V |
| DC Output Current, into Outputs                     | 30mA          |
| DC Input Current                                    | -30 to +5.0mA |

## ELECTRICAL CHARACTERISTICS

The Following Conditions Apply Unless Otherwise Specified:

|                     |                                     |                                 |              |              |
|---------------------|-------------------------------------|---------------------------------|--------------|--------------|
| Am2965/66XC, DC, PC | $T_A = 0$ to $70^\circ\text{C}$     | $V_{CC} = 5.0\text{V} \pm 10\%$ | (MIN = 4.50V | MAX = 5.50V) |
| Am2965/66XM, DM     | $T_A = -55$ to $+125^\circ\text{C}$ | $V_{CC} = 5.0\text{V} \pm 10\%$ | (MIN = 4.50V | MAX = 5.50V) |
| Am2965/66FM         | $T_C = -55$ to $+125^\circ\text{C}$ | $V_{CC} = 5.0\text{V} \pm 10\%$ | (MIN = 4.50V | MAX = 5.50V) |

## DC CHARACTERISTICS OVER OPERATING RANGE

| Parameters | Description                           | Test Conditions (Note 1)  | Min                                   | Typ<br>(Note 2)        | Max        | Units         |
|------------|---------------------------------------|---|---------------------------------------|------------------------|------------|---------------|
| $V_{OH}$   | Output High Voltage                   | $V_{CC} = \text{MIN}$<br>$V_{IN} = V_{IH}$ or $V_{IL}$<br>$I_{OH} = -100\mu\text{A}$                      | $V_{CC} - 1.15$                       | $V_{CC} - 0.7\text{V}$ |            | Volts         |
| $V_{OL}$   | Output LOW Voltage                    | $V_{CC} = \text{MIN}$<br>$V_{IN} = V_{IH}$ or $V_{IL}$<br>$I_{OL} = 1\text{mA}$<br>$I_{OL} = 12\text{mA}$ |                                       |                        | 0.5<br>0.8 | Volts         |
| $V_{IH}$   | Input HIGH Level                      | Guaranteed input logical HIGH voltage for all inputs  | 2.0                                   |                        |            | Volts         |
| $V_{IL}$   | Input LOW Level                       | Guaranteed input logical LOW voltage for all inputs   |                                       |                        | 0.8        | Volts         |
| $V_I$      | Input Clamp Voltage                   | $V_{CC} = \text{MIN}$ , $I_{IN} = -18\text{mA}$   |                                       |                        | -1.2       | Volts         |
| $I_{IL}$   | Input LOW Current                     | $V_{CC} = \text{MAX}$ , $V_{IN} = 0.4\text{V}$  |                                       |                        | -200       | $\mu\text{A}$ |
| $I_{IH}$   | Input HIGH Current                    | $V_{CC} = \text{MAX}$ , $V_{IN} = 2.7\text{V}$  |                                       |                        | 20         | $\mu\text{A}$ |
| $I_I$      | Input HIGH Current                    | $V_{CC} = \text{MAX}$ , $V_{IN} = 7.0\text{V}$  |                                       |                        | 0.1        | mA            |
| $I_{OZH}$  | Off-State Current                     | $V_O = 2.7\text{V}$   |                                       |                        | 100        | $\mu\text{A}$ |
| $I_{OZL}$  | Off-State Current                     | $V_O = 0.4\text{V}$   |                                       |                        | -200       | $\mu\text{A}$ |
| $I_{OL}$   | Output Sink Current                   | $V_{OL} = 2.0\text{V}$  | 35                                    |                        |            | mA            |
| $I_{OH}$   | Output Source Current                 | $V_{OH} = 2.0\text{V}$  | -35                                   |                        |            | mA            |
| $I_{SC}$   | Output Short Circuit Current (Note 3) | $V_{CC} = \text{MAX}$   | -60<br>(see $I_{OH}$ )                |                        | -200       | mA            |
| $I_{CC}$   | Supply Current                        | All Outputs HIGH  |                                       | 24                     | 50         | mA            |
|            |                                       | All Outputs LOW   | $V_{CC} = \text{MAX}$<br>Outputs Open | 86                     | 125        |               |
|            |                                       | All Outputs Hi-Z  |                                       | 86                     | 125        |               |
|            |                                       | All Outputs HIGH  | $V_{CC} = \text{MAX}$<br>Outputs Open | 53                     | 75         |               |
|            |                                       | All Outputs LOW   |                                       | 92                     | 130        |               |
|            |                                       | All Outputs Hi-Z  |                                       | 116                    | 150        |               |

Notes: 1. For conditions shown as MIN or MAX, use the appropriate value specified under Electrical Characteristics for the applicable device type.

2. Typical limits are at  $V_{CC} = 5.0\text{V}$ ,  $25^\circ\text{C}$  ambient and maximum loading.

3. Not more than one output should be shorted at a time. Duration of the short circuit test should not exceed one second.



## Am2965 • Am2966

## SWITCHING CHARACTERISTICS

(T<sub>A</sub> = +25°C, V<sub>CC</sub> = 5.0V)

| Parameters        | Description                                    | Test Conditions  | Min                    | Typ  | Max              | Units |
|-------------------|--|--|------------------------|------|------------------|-------|
| t <sub>PLH</sub>  | Propagation Delay Time from LOW-to-HIGH Output | Figure 1 Test Circuit<br>Figure 3 Voltage Levels and Waveforms | C <sub>L</sub> = 0pF   | 6    | (Note 4)         | ns    |
|                   |  |  | C <sub>L</sub> = 50pF  | 6    | 9                |       |
|                   |  |  | C <sub>L</sub> = 500pF | 15   | 22               |       |
| t <sub>PHL</sub>  | Propagation Delay Time from HIGH-to-LOW Output |  | C <sub>L</sub> = 0pF   | 4    | (Note 4)         | ns    |
|                   |  |  | C <sub>L</sub> = 50pF  | 6    | 12               |       |
|                   |  |  | C <sub>L</sub> = 500pF | 20   | 30               |       |
| t <sub>PLZ</sub>  | Output Disable Time from LOW, HIGH             | Figures 2 and 4, S = 1   |                        | 13   | 20               | ns    |
| t <sub>PHZ</sub>  |  | Figures 2 and 4, S = 2   |                        | 8    | 12               |       |
| t <sub>PZL</sub>  | Output Enable Time from LOW, HIGH              | Figures 2 and 4, S = 1   |                        | 13   | 20               | ns    |
| t <sub>PZH</sub>  |  | Figures 2 and 4, S = 2   |                        | 13   | 20               |       |
| t <sub>SKEW</sub> | Output-to-Output Skew                          | Figures 1 and 3, C <sub>L</sub> = 50pF                         |                        | ±0.5 | ±3.0<br>(Note 5) | ns    |
| V <sub>ONP</sub>  | Output Voltage Undershoot                      | Figures 1 and 3, C <sub>L</sub> = 50pF                         |                        | 0    | -0.5             | Volts |

2

SWITCHING CHARACTERISTICS  
OVER OPERATING RANGE (Note 6)

| Parameters       |  |  | Description            | Test Conditions | COM'L   |     | MIL (Note 7)  |       | Units |
|------------------|--|--|------------------------|-----------------|---|-----|---|-------|-------|
|                  |  |  |                        |                 | T <sub>A</sub> = 0 to 70°C<br>V <sub>CC</sub> = 5.0V ±10% |     | T <sub>A</sub> = -55 to +125°C<br>V <sub>CC</sub> = 5.0V ±10% |       |       |
|                  |  |  |                        |                 | Min   | Max | Min   | Max   |       |
| t <sub>PLH</sub> | Propagation Delay Time<br>LOW-to-HIGH Output | Figures 1 and 3                        | C <sub>L</sub> = 50pF  | 4               | 20  | 4   | 20  | ns    |       |
|                  |  |  | C <sub>L</sub> = 500pF | 13              | 40  | 13  | 40  |       |       |
| t <sub>PHL</sub> | Propagation Delay Time<br>HIGH-to-LOW Output | Figures 1 and 3                        | C <sub>L</sub> = 50pF  | 4               | 24  | 4   | 24  | ns    |       |
|                  |  |  | C <sub>L</sub> = 500pF | 17              | 50  | 17  | 50  |       |       |
| t <sub>PLZ</sub> | Output Disable Time from<br>LOW, HIGH        | Figures 2 and 4                        | S = 1                  |                 | 24  |     | 24  | ns    |       |
| t <sub>PHZ</sub> |  |  | S = 2                  |                 | 16  |     | 16  |       |       |
| t <sub>PZL</sub> | Output Enable Time from<br>LOW, HIGH         | Figures 2 and 4                        | S = 1                  |                 | 28  |     | 28  | ns    |       |
| t <sub>PZH</sub> |  |  | S = 2                  |                 | 28  |     | 28  |       |       |
| V <sub>ONP</sub> | Output Voltage Undershoot                    | Figures 1 and 3, C <sub>L</sub> = 50pF |                        |                 | -0.5  |     | -0.5  | Volts |       |

Notes: 4. Typical time shown for reference only – not tested.

5. Time Skew specification is guaranteed by design but not tested.

6. AC performance over the operating temperature range is guaranteed by testing defined in Group A, Subgroup 9.

7. T<sub>C</sub> = -55 to +125°C for Flatpak versions.

## SWITCHING TEST CIRCUITS

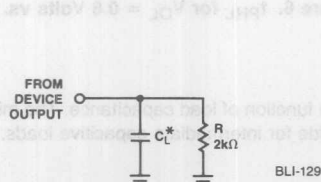
\*t<sub>pd</sub> specified at C = 50 and 500pF.

Figure 1. Capacitive Load Switching.

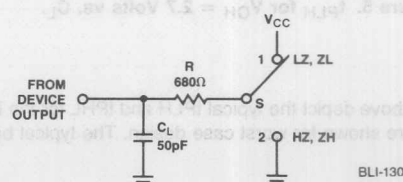


Figure 2. Three-State Enable/Disable.

## TYPICAL SWITCHING CHARACTERISTICS

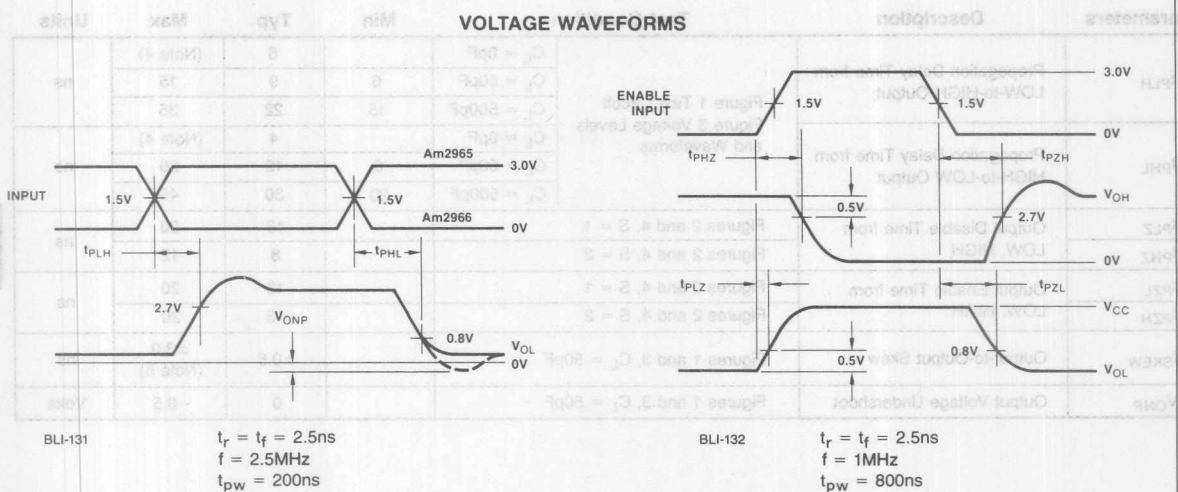


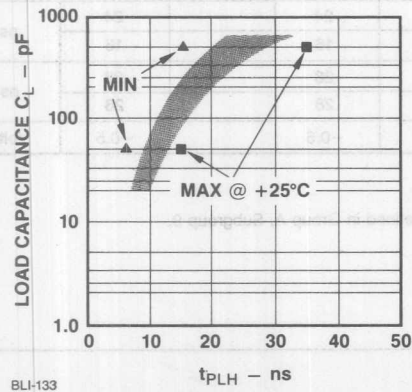
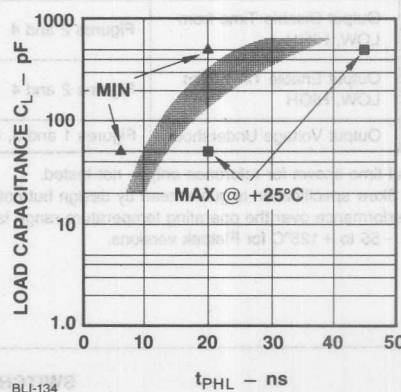
Figure 3. Output Drive Levels.

Figure 4. Three-State Control Levels.

The RAM Driver symmetrical output design offers significant improvement over a standard Schottky output by providing a balanced drive output impedance ( $\approx 33\Omega$  both HIGH and LOW), and by pulling up to MOS  $V_{OH}$  levels ( $V_{CC} - 1.15\text{V}$ ). External resistors, not required with the RAM Driver, protect standard Schottky drivers from error causing undershoot but also slow the output rise by adding to the internal R.

The RAM Driver is optimized to drive LOW at maximum speed based on safe undershoot control and to drive HIGH with a symmetrical speed characteristic. This is an optimum approach because the dominant RAM loading characteristic is input capacitance.

The curves shown below provide performance characteristics typical of both the inverting (Am2965) and non-inverting (Am2966) RAM Drivers.

Figure 5.  $t_{PLH}$  for  $V_{OH} = 2.7$  Volts vs.  $C_L$ .Figure 6.  $t_{PHL}$  for  $V_{OL} = 0.8$  Volts vs.  $C_L$ .

The curves above depict the typical  $t_{PLH}$  and  $t_{PHL}$  for the RAM Driver outputs as a function of load capacitance. The minimums and maximums are shown for worst case design. The typical band is provided as a guide for intermediate capacitive loads.

## 64K/256K X 22-BIT MEMORY



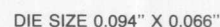
\*Address and  $\overline{\text{RAS}}/\overline{\text{CAS}}$  drivers each drive 22 RAM inputs at each output. Timing skew is minimized by using one device for address lines and one device for  $\overline{\text{RAS}}/\overline{\text{CAS}}$ , spreading the  $\overline{\text{CAS}}$  loading over four drivers to equalize the capacitive load on each driver.

## DYNAMIC MEMORY CONTROL WITH ERROR DETECTION AND CORRECTION

## Am2965



## Am2966



# Am2965 • Am2966

Order the part number according to the table below to obtain the desired package, temperature, and screening level.

| Am2965<br>Order Number | Am2966<br>Order Number | Package<br>Type | Temperature<br>Range | Screening<br>Level                                   |
|------------------------|------------------------|-----------------|----------------------|--|
| AM2965PC               | AM2966PC               | P-20            | C                    | C-1  |
| AM2965DC               | AM2966DC               | D-20            | C                    | C-1  |
| AM2965DC-B             | AM2966DC-B             | D-20            | C                    | B-1  |
| AM2965DM               | AM2966DM               | D-20            | M                    | C-3  |
| AM2965DMB              | AM2966DMB              | D-20            | M                    | B-3  |
| AM2965FM               | AM2966FM               | F-20            | M                    | C-3  |
| AM2965FMB              | AM2966FMB              | F-20            | M                    | B-3  |
| AM2965XC               | AM2966XC               | Dice            | C                    | Visual inspection<br>to MIL-STD-883<br>Method 2010B. |
| AM2965XM               | AM2966XM               | Dice            | M                    |  |

- Notes: 1. P = Molded DIP, D = Hermetic DIP, F = Flatpak. Number following letter is number of leads. See Appendix B for detailed outline. Where Appendix B contains several dash numbers, any of the variations of the package may be used unless otherwise specified.  
2. C = 0 to 70°C,  $V_{CC} = 4.50V$  to 5.50V, M = -55 to +125°C,  $V_{CC} = 4.50V$  to 5.50V.  
3. See Appendix A for details of screening. Levels C-1 and C-3 conform to MIL-STD-883, Class C. Level B-3 conforms to MIL-STD-883, Class B.

# Am29112

## Interruptable 8-Bit Microprogram Sequencer

### ADVANCE INFORMATION

#### DISTINCTIVE CHARACTERISTICS

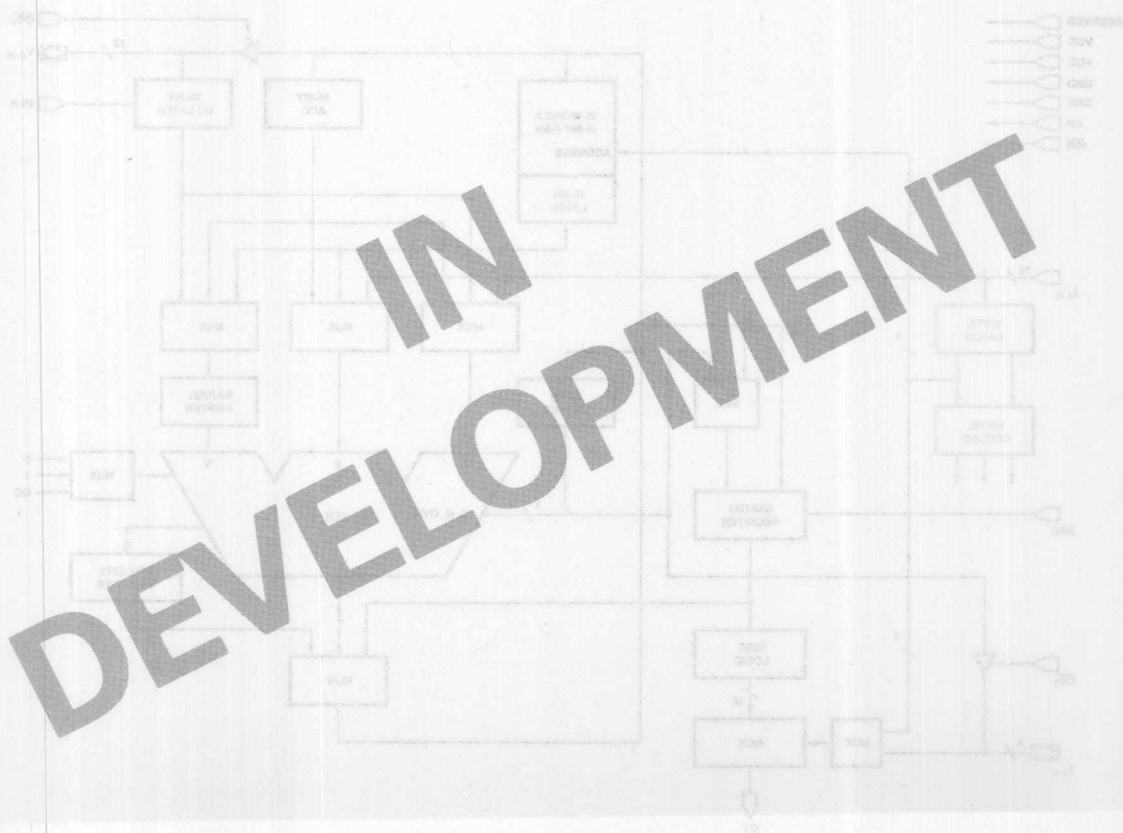
- **FAST**  
Designed to operate in 10MHz microprogrammed systems.
- **Expandable**  
One Am29112 directly addresses up to 256 words of microcode. Two Am29112's can directly address up to 64K words of microcode.
- **Interruptable**  
The Am29112 may be interrupted at the completion of a microcycle. Internal states are saved on the stack and the Am29112 branches automatically to the interrupt service routine.

- **Many Addressing Modes**  
Immediate, relative, and N-Way addressing are all possible with the Am29112.
- **31-Level Stack**  
On-chip 31-level stack is used for subroutines, interrupts and loops.
- **Single or Double Pipeline**  
The Am29112 may be configured for either single-level pipeline or double-level pipeline operation.
- **40-Pin Dual-in-Line Package**

Note: Am2900 High Performance Controller Products Family.

For information on using the Am29112 with other Am2900 High Performance Controller Products, refer to page 2-339.

#### BLOCK DIAGRAM





# Am29116

## 16-Bit Bipolar Microprocessor

### ADVANCE INFORMATION

#### DISTINCTIVE CHARACTERISTICS

##### • Designed for Controller Applications

Instruction set designed for high performance peripheral controllers, communications controllers, industrial controllers and digital modems . . . but general purpose, too. Excellent solution for applications requiring speed and bit-manipulation power.

##### • FAST

Design objective of 100ns maximum microcycle time for all instructions. Allows a 10MHz clock rate.

##### • Powerful Instruction Set

All instructions executable in single cycle on full 16-bit word or on 8-bit byte:

- Add, Subtract
- N-bit Rotate
- Shift-Up/Shift-Down

- Set-Bit/Reset-Bit
- Add/Subtract  $2^N$
- Rotate & Merge
- Rotate & Compare
- CRC Generation
- Priority Encode

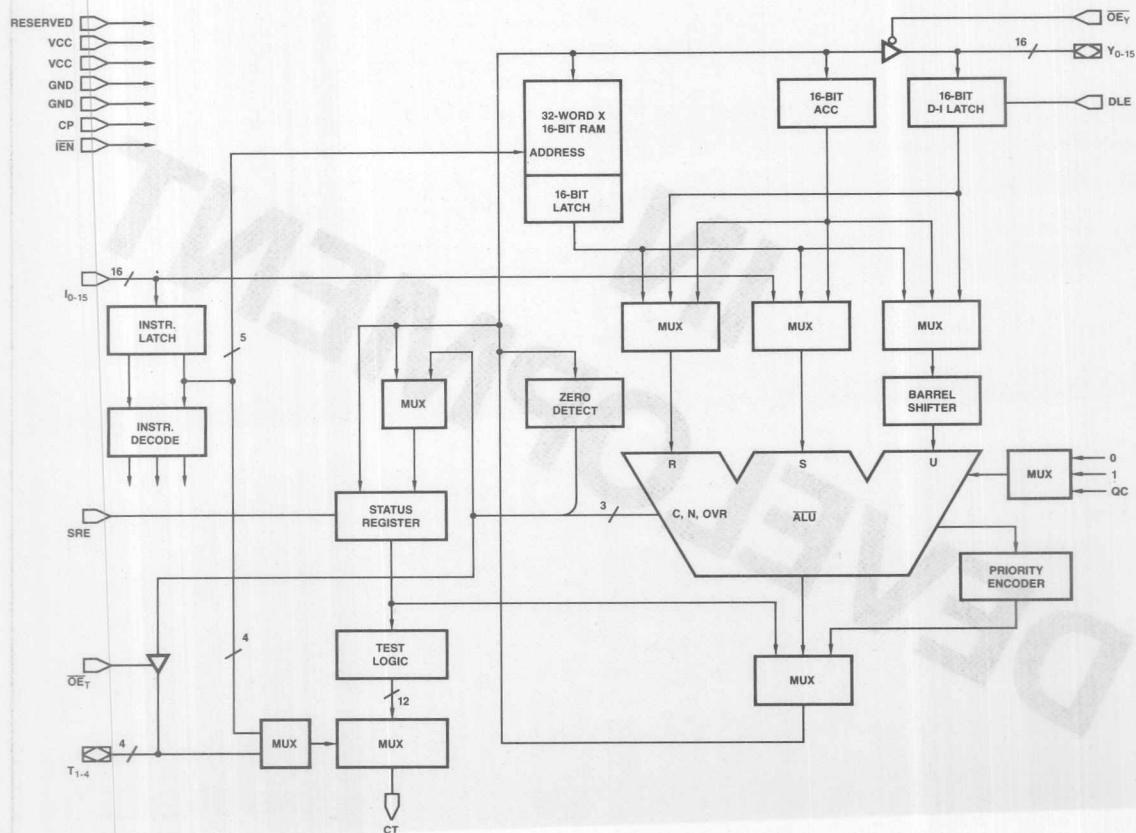
##### • Powerful Data Manipulation

Full 16-bit data path. 32 registers on chip. Direct data input for immediate mode instructions.

Note: Am2900 High Performance Controller Products Family.

Refer to the following page for more information on the Am2900 High Performance Controller Products Family.

#### BLOCK DIAGRAM



MPR-740

# Am2900 HIGH PERFORMANCE CONTROLLER PRODUCTS

## A Better Way is Coming

A new family of products coming from Advanced Micro Devices makes high-performance controller design a snap.

## Microprogramming: Best for Computers, Best for Controllers

Microprogramming, long the preferred approach for computer design, offers lots of advantages in controllers as well. The ease with which the functions of a microprogrammed controller can be enhanced and modified made the original 2900 Family popular for many disk, printer and communications controllers. The high speed operation of these microprogrammed systems makes it

possible to handle higher data rates from newer peripheral devices and to build intelligence into the controller.

But the original 2900 products are architecturally oriented toward computers, with design features optimized for arithmetic functions and short sequences of microinstructions. MOS processors are good choices for many low speed applications, but when the demand for speed and intelligence goes up, they cannot keep pace. Controllers need something better.

Something better has been added to our 2900 Family: New products especially for controllers. Through 1980 and 1981, we'll be bringing you new products whose architectural features are optimized for bit manipulation, character handling, data communication and long, sophisticated microprograms. (Continued on next page)

2

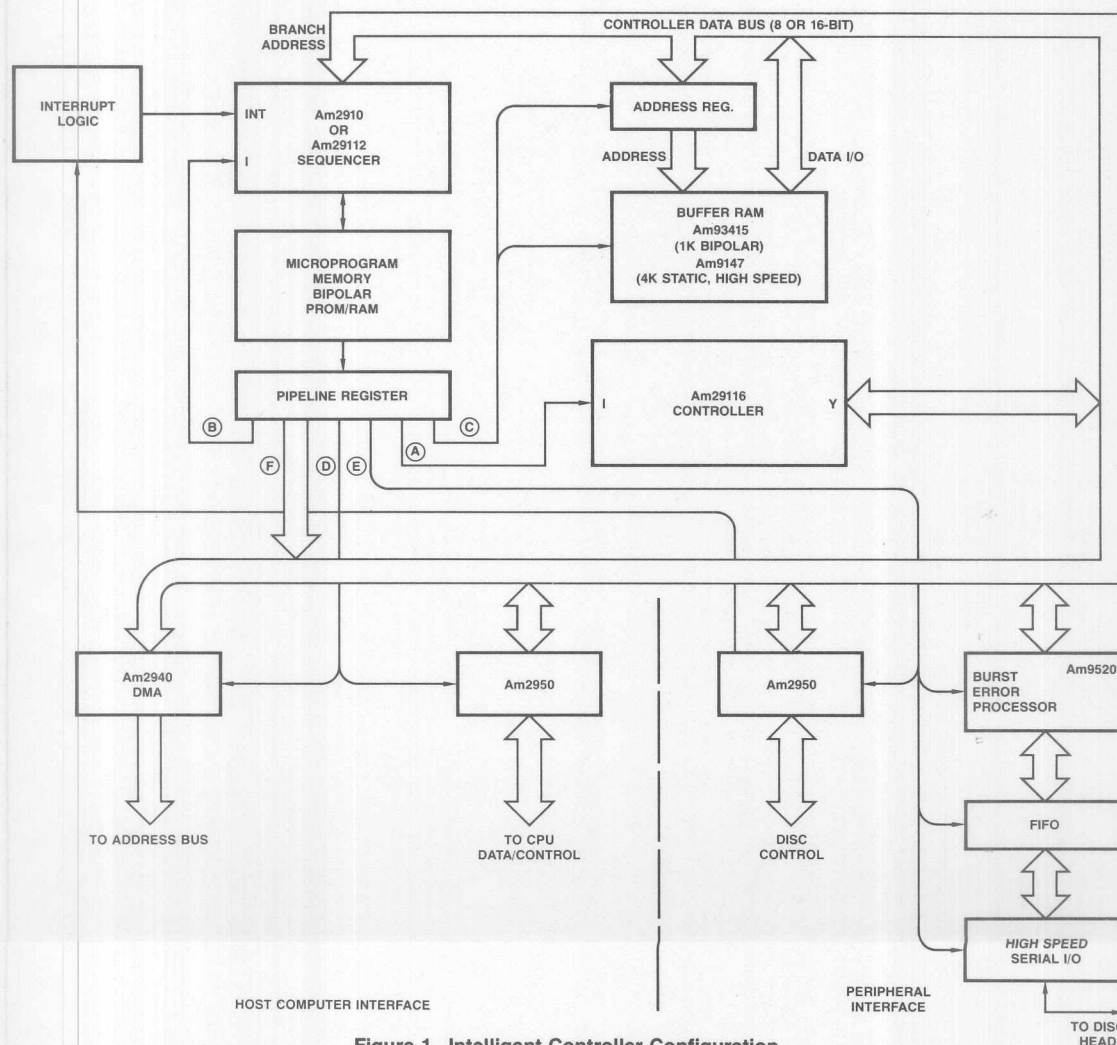


Figure 1. Intelligent Controller Configuration.

**Am2900** — a 16-bit bipolar microprocessor. It's not a "bit slice" — it's a complete 16-bit processor, with ALU, working registers and status register. It can do computer instructions like add and subtract, but it's more than a computer. The Am29116 has instructions just for controllers — instructions not available in any other microprocessor. And it's fast — designed to run at 10MHz clock rate, to keep up with the needs of today's high performance peripherals and tomorrow's high speed communication channels.

#### A Whole Family of Fast LSI Controller Parts

There's more to our controller family than just the Am29116. A new sequencer, the Am29112, has been expressly designed for 10MHz microprogram control, with features like real-time interrupt servicing and deep subroutining. Rapid internal data transfer is handled by the Am2940 DMA Address Generator and by the Am2950 handshaking I/O port. The Am9520 Burst Error Processor will provide a solution for error correction on disk

and tape. It's the better solution for high data rate and highly intelligent control problems.

#### Typical Configuration Using the 2900 Controller Family

A typical intelligent controller configuration is shown in Figure 1. The basic controller consists of the Am29116, a microprogram control unit and a high speed buffer memory. Each microinstruction includes: A) a 16-bit instruction field to the Am29116, B) next-microinstruction selection bits, C) control for the buffer memory, D and E) control for the interface circuits and F) possibly an 8 or 16-bit data field.

Interface circuits like the Am2940 and Am2950 are used to provide DMA and to pass data between the controller and the host computer. Other circuits are used to interface to the peripheral. In this example, a disk interface is shown with a serial-parallel converter, a FIFO and a burst error processor. Controllers for other peripherals use identical hardware except for the peripheral interface itself.

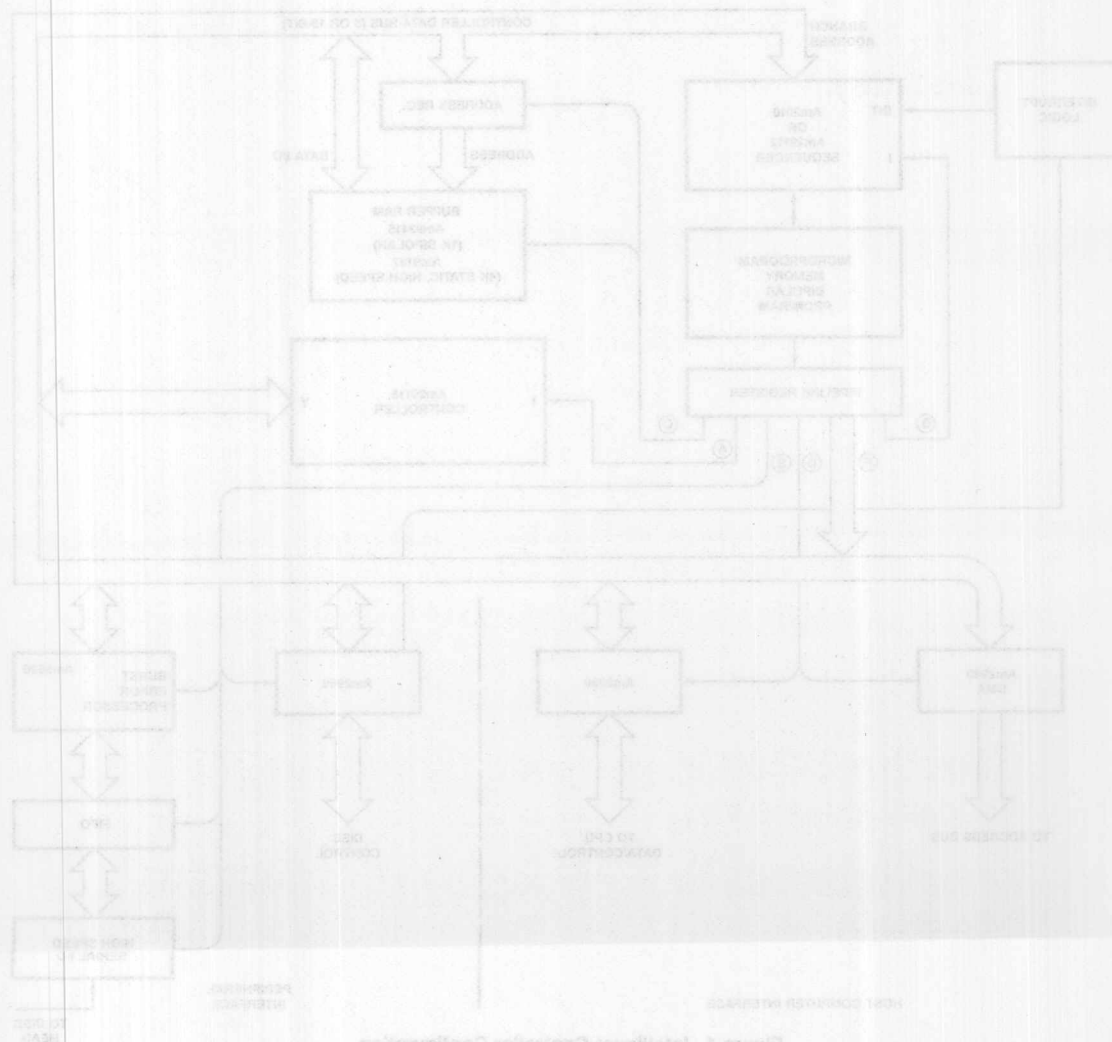


Figure 1: Intelligent Controller Configuration.

# Am29700 • Am29701

Non-Inverting Schottky 64-Bit Random Access Memories

2

Refer to  
**Am27S06 • Am27S07**  
in the Bipolar Memory Section

The Am29700 is replaced by the Am27S06  
(open collector).

The Am29701 is replaced by the Am27S07  
(3-state).

# Am29702 • Am29703

Schottky 64-Bit Random Access Memories

Refer to  
**Am27S02 • Am27S03**  
in the Bipolar Memory Section

The Am29702 is replaced by the Am27S02  
(open collector).

The Am29703 is replaced by the Am27S03  
(3-state).

# Am29705

## 16-Word by 4-Bit 2-Port RAM

### Distinctive Characteristics

- 16-word by 4-bit, 2-port RAM
- Two output ports, each with separate output control
- Separate four-bit latches on each output port
- Data output is non-inverting with respect to data input

- Chip Select and Write Enable inputs for ease in cascading
- Advanced Low-Power Schottky processing
- 100% reliability testing in compliance with MIL-STD-883

### FUNCTIONAL DESCRIPTION

The Am29705 is a 16-word by 4-bit, two-port RAM built using advanced Low-Power Schottky processing. This RAM features two separate output ports such that any two 4-bit words can be read from these outputs simultaneously. Each output port has a four-bit latch but a common Latch Enable (LE) input is used to control all eight latches. The device has two Write Enable (WE) inputs and is designed such that the Write Enable 1 (WE<sub>1</sub>) and Latch Enable (LE) inputs can be wired together to make the operation of the RAM appear edge triggered.

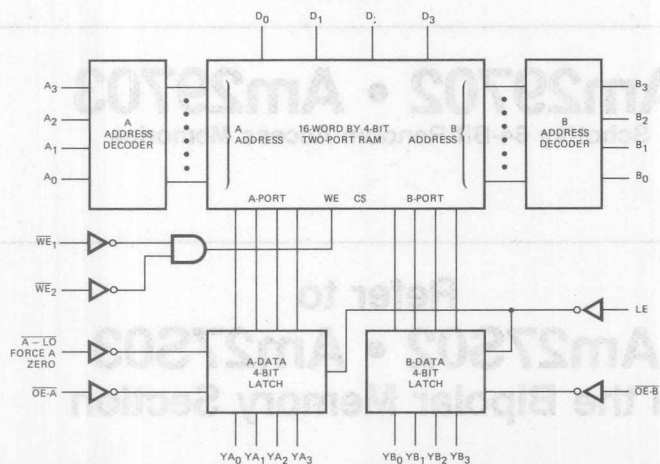
The device has a fully decoded four-bit A-address field to address any of the 16 memory words for the A-output port. Likewise, a four-bit B-address input is used to simultaneously select any of the 16 words for presentation at the B-output port. New incoming data is written into the four-bit RAM

word selected by the B-address. The D inputs are used to load new data into the device.

The Am29705 features three-state outputs so that several devices can be cascaded to increase the total number of memory words in the system. The A-output port is in the high-impedance state when the OE-A input is HIGH. Likewise, the B-output port is in the high-impedance state when the OE-B input is HIGH. Four devices can be paralleled using only one Am25LS139 decoder for output control.

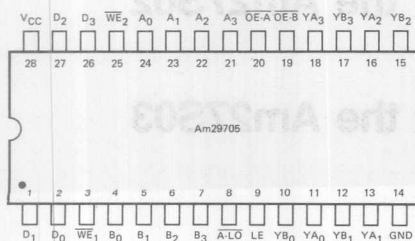
The Write Enable inputs control the writing of new data into the RAM. When both Write Enable inputs are LOW, new data is written into the word selected by the B-address field. When either Write Enable input is HIGH, no data is written into the RAM.

### LOGIC DIAGRAM



MPR-251

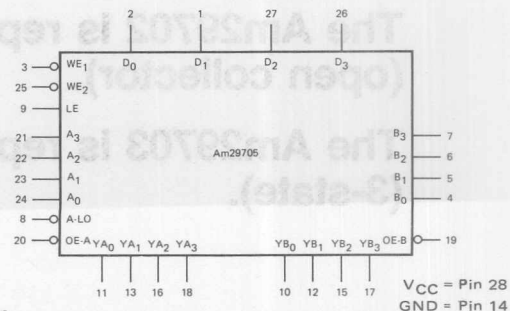
### CONNECTION DIAGRAM Top View



Note: Pin 1 is marked for orientation.

MPR-252

### LOGIC SYMBOL



V<sub>CC</sub> = Pin 28  
GND = Pin 14

MPR-253



**MAXIMUM RATINGS** (Above which the useful life may be impaired)

|   |                                |
|---|--------------------------------|
| Storage Temperature                                 | –65°C to +150°C                |
| Temperature (Ambient) Under Bias                    | –55°C to +125°C                |
| Supply Voltage to Ground Potential Continuous       | –0.5V to +7.0V                 |
| DC Voltage Applied to Outputs for HIGH Output State | –0.5V to +V <sub>CC</sub> max. |
| DC Input Voltage                                    | –0.5V to +5.5V                 |
| DC Output Current, Into Outputs                     | 30mA                           |
| DC Input Current                                    | –30mA to +5.0mA                |

**ELECTRICAL CHARACTERISTICS OVER OPERATING TEMPERATURE RANGE** (Unless Otherwise Noted)

Am29705XC T<sub>A</sub> = 0°C to +70°C V<sub>CC</sub> = 5.0V ±5% (COM'L) MIN. = 4.75V MAX. = 5.25V  
 Am29705XM T<sub>A</sub> = –55°C to +125°C V<sub>CC</sub> = 5.0V ±10% (MIL) MIN. = 4.50V MAX. = 5.50V

| Parameters      | Description                               | Test Conditions (Note 1)  | Min.  | Typ.<br>(Note 2) | Max.                            | Units |
|-----------------|---|---|---|------------------|---------------------------------|-------|
| V <sub>OH</sub> | Output HIGH Voltage                       | V <sub>CC</sub> = MIN.<br>V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>            | MIL, I <sub>OH</sub> = –2.0mA<br>2.4<br>COM'L, I <sub>OH</sub> = –4.0mA<br>2.4  |                  |                                 | Volts |
| V <sub>OL</sub> | Output LOW Voltage                        | V <sub>CC</sub> = MIN.<br>V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>            | I <sub>OL</sub> = 4.0mA<br>I <sub>OL</sub> = 8.0mA<br>I <sub>OL</sub> = 12mA  |                  | 0.4<br>0.45<br>0.5              | Volts |
| V <sub>IH</sub> | Input HIGH Level                          | Guaranteed input logical HIGH voltage for all inputs                                      | 2.0   |                  |                                 | Volts |
| V <sub>IL</sub> | Input LOW Level                           | Guaranteed input logical LOW voltage for all inputs                                       |   |                  | 0.8                             | Volts |
| V <sub>I</sub>  | Input Clamp Voltage                       | V <sub>CC</sub> = MIN., I <sub>IN</sub> = –18mA   |   |                  | –1.5                            | Volts |
| I <sub>IL</sub> | Input LOW Current                         | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 0.4V  | A <sub>i</sub> , B <sub>i</sub><br>OE-A, OE-B<br>Others   |                  | –0.25<br>–0.54<br>–0.36         | mA    |
| I <sub>IH</sub> | Input HIGH Current                        | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 2.7V  |   |                  | 20                              | μA    |
| I <sub>I</sub>  | Input HIGH Current                        | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 5.5V  |   |                  | 0.1                             | mA    |
| I <sub>O</sub>  | Off State (High Impedance) Output Current | V <sub>CC</sub> = MAX.<br>V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>            | V <sub>O</sub> = 2.7V<br>V <sub>O</sub> = 0.4V  |                  | 20<br>–20                       | μA    |
| I <sub>SC</sub> | Output Short Circuit Current (Note 3)     | V <sub>CC</sub> = MAX.  | –30   |                  | –85                             | mA    |
| I <sub>CC</sub> | Power Supply Current                      | V <sub>CC</sub> = MAX.<br>(Worst case I <sub>CC</sub> is at minimum temperature) (Note 4) | T <sub>A</sub> = 25°C<br>T <sub>A</sub> = 0°C to +70°C<br>T <sub>A</sub> = 70°C<br>T <sub>C</sub> = –55°C to +125°C<br>T <sub>C</sub> = 125°C | 121              | 195<br>210<br>170<br>210<br>150 | mA    |

- Notes: 1. For conditions shown as MIN. or MAX., use the appropriate value specified under Electrical Characteristics for the applicable device type.  
 2. Typical limits are at V<sub>CC</sub> = 5.0V, 25°C ambient and maximum loading.  
 3. Not more than one output should be shorted at a time. Duration of the short circuit test should not exceed one second.  
 4. All inputs grounded except OE-A and OE-B = 2.4V.

**SWITCHING CHARACTERISTICS**

(Input Levels = 0V and 3.0V, Transitions Measured at 1.5V)

Maximum Combinational Delays (in ns) (R<sub>L</sub> = 390Ω, C<sub>L</sub> = 50pF)

| Parameters    | From                                 | To                     | Conditions            | T <sub>A</sub> = 0°C to +70°C<br>V <sub>CC</sub> = 4.75V to 5.25V | T <sub>C</sub> = –55°C to +125°C<br>V <sub>CC</sub> = 4.5V to 5.5V |
|---------------|--------------------------------------|------------------------|-----------------------|---|--|
| Access Time   | A Address Stable or B Address Stable | YA Stable or YB Stable | LE = HIGH             | 53  | 58   |
| Turn-On Time  | OE-A or OE-B LOW                     | YA or YB Stable        |                       | 30  | 30   |
| Turn-Off Time | OE-A or OE-B HIGH                    | YA or YB Off           | C <sub>L</sub> = 50pF | 20  | 20   |
| Reset Time    | A-LO LOW                             | YA LOW                 |                       | 35  | 35   |
| Enable Time   | LE HIGH                              | YA and YB Stable       |                       | 32  | 32   |

| Parameters                         | From                        | To                          | Conditions            | Max. | Max. |
|------------------------------------|-----------------------------|-----------------------------|-----------------------|------|------|
| Data Set-up Time                   | D Stable                    | Either $\overline{WE}$ HIGH |                       | 20   | 25   |
| Data Hold Time                     | Either $\overline{WE}$ HIGH | D Changing                  |                       | 3    | 5    |
| Address Set-up Time                | B Stable                    | Both $\overline{WE}$ LOW    |                       | 5    | 5    |
| Address Hold Time                  | Either $\overline{WE}$ HIGH | B Changing                  |                       | 0    | 0    |
| Latch Close Before Write Begins    | LE LOW                      | $\overline{WE}_1$ LOW       | $\overline{WE}_2$ LOW | 0    | 0    |
|                                    | LE LOW                      | $\overline{WE}_2$ LOW       | $\overline{WE}_1$ LOW | 0    | 0    |
| Address Set-up Before Latch Closes | A or B Stable               | LE LOW                      |                       | 45   | 50   |

#### Minimum Pulse Widths

| Parameters          | Input             | Pulse         | Conditions            | Max. | Max. |
|---------------------|-------------------|---------------|-----------------------|------|------|
| Write Pulse Width   | $\overline{WE}_1$ | HIGH-LOW-HIGH | $\overline{WE}_2$ LOW | 25   | 25   |
|                     | $\overline{WE}_2$ | HIGH-LOW-HIGH | $\overline{WE}_1$ LOW | 20   | 20   |
| A Latch Reset Pulse | A-LO              | HIGH-LOW-HIGH |                       | 20   | 20   |
| Latch Data Capture  | LE                | LOW-HIGH-LOW  |                       | 20   | 25   |

$T_A = 0^\circ\text{C to } +70^\circ\text{C}$   
 $V_{CC} = 5.0\text{V} \pm 5\%$

$T_A = -55^\circ\text{C to } +125^\circ\text{C}$   
 $V_{CC} = 5.0\text{V} \pm 10\%$

#### FUNCTION TABLES

##### WRITE CONTROL

| $\overline{WE}_1$ | $\overline{WE}_2$ | Function       | RAM Outputs at Latch Inputs |               |
|-------------------|-------------------|----------------|-----------------------------|---------------|
|                   |                   |                | A-Port                      | B-Port        |
| L                 | L                 | Write D Into B | A data (A $\neq$ B)         | Not Specified |
| X                 | H                 | No write       | A data                      | B data        |
| H                 | X                 | No write       | A data                      | B data        |

H = HIGH

L = LOW

X = Don't care

##### YA READ

| Inputs            |      |    | YA Output         | Function            |
|-------------------|------|----|-------------------|---------------------|
| $\overline{OE}-A$ | A-LO | LE |                   |                     |
| H                 | X    | X  | Z                 | High impedance      |
| L                 | L    | X  | L                 | Force YA LOW        |
| L                 | H    | H  | A - Port RAM data | Latches transparent |
| L                 | H    | L  | NC                | Latches retain data |

H = HIGH

L = LOW

X = Don't care

Z = High impedance

NC = No change

##### YB READ

| Inputs            |    | YB Output         | Function            |
|-------------------|----|-------------------|---------------------|
| $\overline{OE}-B$ | LE |                   |                     |
| H                 | X  | Z                 | High impedance      |
| L                 | H  | B - Port RAM data | Latches transparent |
| L                 | L  | NC                | Latches retain data |

H = HIGH

L = LOW

X = Don't care

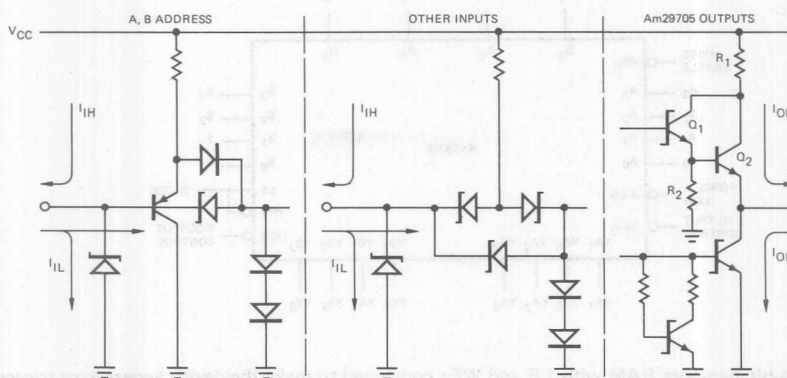
Z = High impedance

NC = No change

#### LOADING RULES (In Unit Loads)

| Input/Output      | Pin No.'s | Fan-out         |                 |
|-------------------|-----------|-----------------|-----------------|
|                   |           | Input Unit Load | Output HIGH LOW |
| D <sub>1</sub>    | 1         | 1               | — —             |
| D <sub>0</sub>    | 2         | 1               | — —             |
| $\overline{WE}_1$ | 3         | 1               | — —             |
| B <sub>0</sub>    | 4         | 0.55            | — —             |
| B <sub>1</sub>    | 5         | 0.55            | — —             |
| B <sub>2</sub>    | 6         | 0.55            | — —             |
| B <sub>3</sub>    | 7         | 0.55            | — —             |
| A-LO              | 8         | 1               | — —             |
| LE                | 9         | 1               | — —             |
| YB <sub>0</sub>   | 10        | —               | 100/200 33      |
| YA <sub>0</sub>   | 11        | —               | 100/200 33      |
| YB <sub>1</sub>   | 12        | —               | 100/200 33      |
| YA <sub>1</sub>   | 13        | —               | 100/200 33      |
| GND               | 14        | —               | — —             |
| YB <sub>2</sub>   | 15        | —               | 100/200 33      |
| YA <sub>2</sub>   | 16        | —               | 100/200 33      |
| YB <sub>3</sub>   | 17        | —               | 100/200 33      |
| YA <sub>3</sub>   | 18        | —               | 100/200 33      |
| $\overline{OE}-B$ | 19        | 1               | — —             |
| $\overline{OE}-A$ | 20        | 1               | — —             |
| A <sub>3</sub>    | 21        | 0.55            | — —             |
| A <sub>2</sub>    | 22        | 0.55            | — —             |
| A <sub>1</sub>    | 23        | 0.55            | — —             |
| A <sub>0</sub>    | 24        | 0.55            | — —             |
| $\overline{WE}_2$ | 25        | 1               | — —             |
| D <sub>3</sub>    | 26        | 1               | — —             |
| D <sub>2</sub>    | 27        | 1               | — —             |
| V <sub>CC</sub>   | 28        | —               | — —             |

A Low-Power Schottky TTL Unit Load is defined as 20 $\mu$ A measured at 2.7V HIGH and -0.36mA measured at 0.4V LOW.

INPUT/OUTPUT CURRENT  
INTERFACE CONDITIONS

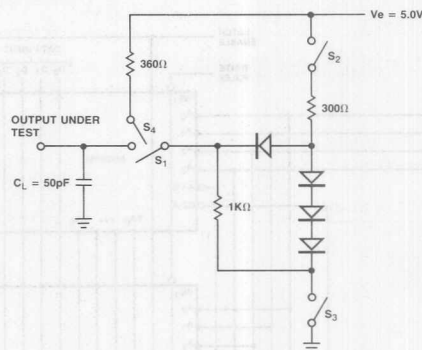
Note: Actual current flow direction shown.

MPR-254

## LOAD CIRCUITS FOR AC TESTS

All delays are measured from 1.5V at the input to 1.5V at the output, except the output disable times which are measured from 1.5V at the input to 0.5V below or above the output level.

1. For function and AC tests except output enable tests  $S_1$ ,  $S_2$  and  $S_3$  are closed while  $S_4$  is open.
2. For output enable tests:  
 $t_{PZH}$ :  $S_1$  and  $S_3$  are closed,  $S_2$  and  $S_4$  are open.  
 $t_{PZL}$ :  $S_1$  and  $S_2$  are closed,  $S_3$  and  $S_4$  are open.
3.  $C_L = 50\text{pF}$  for output disable tests.



MPR-581

## DEFINITION OF TERMS

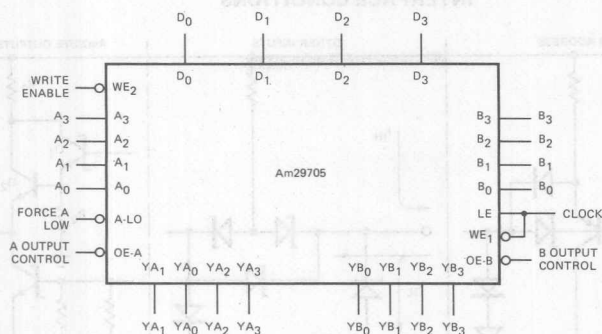
- D<sub>0</sub>, D<sub>1</sub>, D<sub>2</sub>, D<sub>3</sub>** Data Inputs. New data is written into the RAM through these inputs.
- A<sub>0</sub>, A<sub>1</sub>, A<sub>2</sub>, A<sub>3</sub>** The A-address Inputs. The four-bit field presented at the A inputs selects one of the 16 memory words for presentation to the A-Data Latch.
- B<sub>0</sub>, B<sub>1</sub>, B<sub>2</sub>, B<sub>3</sub>** The B-address inputs. The four-bit field presented at the B inputs selects one of the 16 memory words for presentation to the B-Data Latch. The B address field also selects the word into which new data is written.
- YA<sub>0</sub>, YA<sub>1</sub>, YA<sub>2</sub>, YA<sub>3</sub>** The four A-Data Latch Outputs.
- YB<sub>0</sub>, YB<sub>1</sub>, YB<sub>2</sub>, YB<sub>3</sub>** The four B-Data Latch Outputs.
- WE<sub>1</sub>, WE<sub>2</sub>** Write Enables. When both Write Enables are LOW, new data is written into the word selected by the B-address field. If either Write Enable input is HIGH, no new data can be written into the memory.
- OE-A** A-port Output Enable. When OE-A is LOW, data in the A-Data Latch is present at the YA<sub>i</sub> outputs. If OE-A is HIGH, the YA<sub>i</sub> outputs are in the high-impedance (off) state.

**OE-B** B-port Output Enable. When OE-B is LOW, data in the B-Data Latch is present at the YB<sub>i</sub> outputs. When OE-B is HIGH, the YB<sub>i</sub> outputs are in the high-impedance (off) state.

**LE** Latch Enable. The LE input controls the latches for both the RAM A-output port and RAM B-output port. When the LE input is HIGH, the latches are open (transparent) and data from the RAM, as selected by the A and B address fields, is present at the outputs. When LE is LOW, the latches are closed and they retain the last data read from the RAM independent of the current A and B address field inputs.

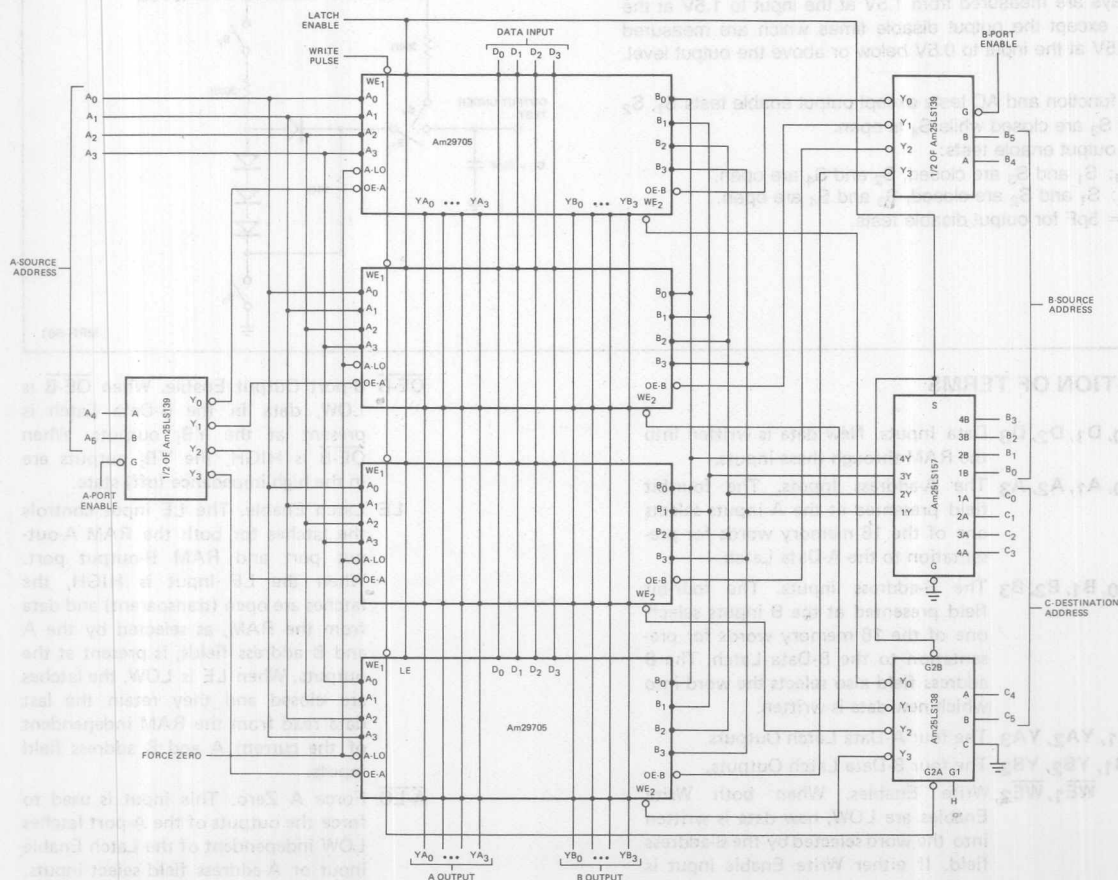
**A-LO** Force A Zero. This input is used to force the outputs of the A-port latches LOW independent of the Latch Enable input or A-address field select inputs. Thus, the A-output bus can be forced LOW using this control signal. When the A-LO input is HIGH, the A latches operate in their normal fashion. Once the A latches are forced LOW, they remain LOW independent of the A-LO input if the latches are closed.

## APPLICATIONS



MPR-257

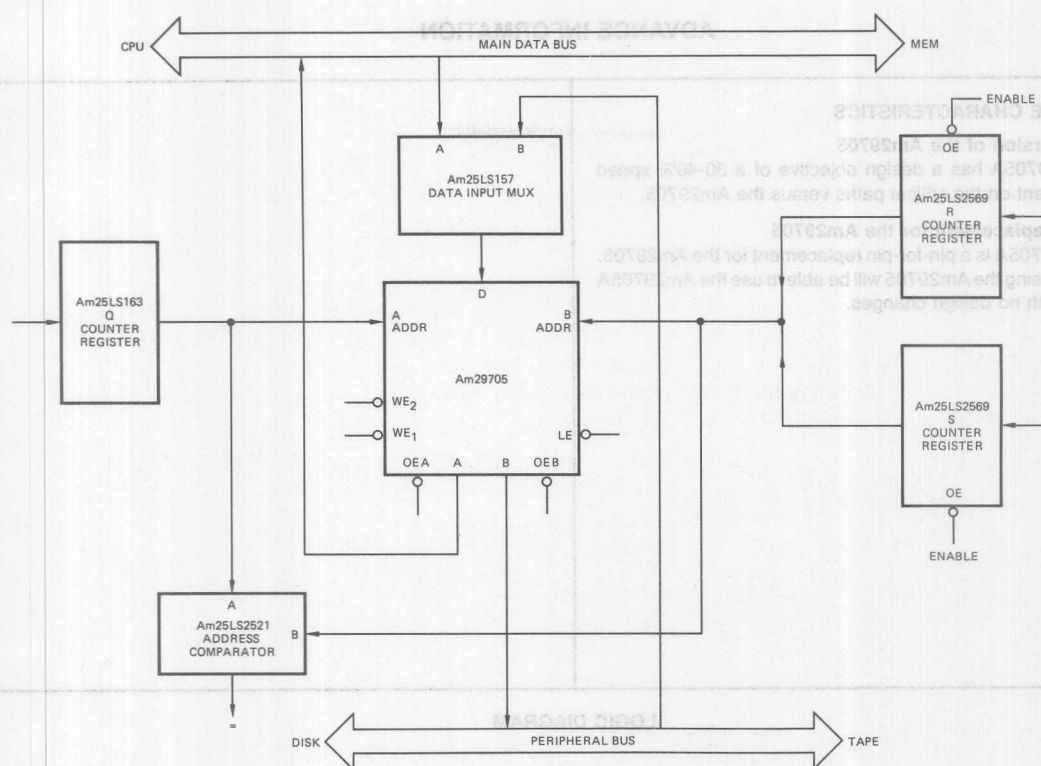
A 16-word by 4-bit two-port RAM with LE and WE<sub>1</sub> connected to make the device appear edge triggered. WE<sub>1</sub> and WE<sub>2</sub> are logically identical but are electrically slightly different. For synchronous operation without possibility of race, WE<sub>1</sub> should be connected to LE.



MPR-258

A 64-word by 4-bit three address memory. Data is read from the A address to the Y<sub>A</sub> outputs and from the B address to the Y<sub>B</sub> outputs while the latch enable is HIGH. When the latch enable goes LOW, the Y<sub>A</sub> and Y<sub>B</sub> data is held in the internal latches, and the RAM B address is switched to the C-destination address lines. A write pulse will then deposit the input data into the location selected by the C address.

## APPLICATIONS (Cont'd)



The Am29705 as a two-way interface buffer. Data may be passed between the main data bus and the peripheral data bus under I/O control. The two-port RAM allows data to be written into buffer storage from a peripheral device, using the B address port and the S counter register, while it is being read into main memory, using the A address port and the Q counter register. This simultaneous read/write capability facilitates DMA transfers because the CPU can ignore write requests from the peripheral device. Data output from CPU to the peripheral device is handled by sequential write and read operations. Data is written into buffer storage from the CPU, using the B address port and the R counter register. It is read onto the peripheral device using the B address port and either the R register, for single word transfers, or the S register, for block transfers.

MPR-259

## ORDERING INFORMATION

Order the part number according to the table below to obtain the desired package, temperature range, and screening level.

| Order Number | Package Type<br>(Note 1) | Operating Range<br>(Note 2) | Screening Level<br>(Note 3)                          |
|--------------|--------------------------|-----------------------------|--|
| AM29705PC    | P-28                     | C                           | C-1  |
| AM29705DC    | D-28                     | C                           | C-1  |
| AM29705DCTB  | D-28                     | C                           | B-2 (Note 4)   |
| AM29705DM    | D-28                     | M                           | C-3  |
| AM29705DM-B  | D-28                     | M                           | B-3  |
| AM29705FM    | F-28-1                   | M                           | C-3  |
| AM29705FM-B  | F-28-1                   | M                           | B-3  |
| AM29705XC    | Dice                     | C                           | Visual inspection<br>to MIL-STD-883<br>Method 2010B. |
| AM29705XM    | Dice                     | M                           |  |

- Notes: 1. P = Molded DIP, D = Hermetic DIP, F = Flat Pak. Number following letter is number of leads. See Appendix B for detailed outline. Where Appendix B contains several dash numbers, any of the variations of the package may be used unless otherwise specified.
2. C = 0°C to +70°C,  $V_{CC}$  = 4.75V to 5.25V, M = -55°C to +125°C,  $V_{CC}$  = 4.50V to 5.50V.
3. See Appendix A for details of screening. Levels C-1 and C-3 conform to MIL-STD-883, Class C. Level B-3 conforms to MIL-STD-883, Class B.
4. 96 hour burn-in.



# Am29705A

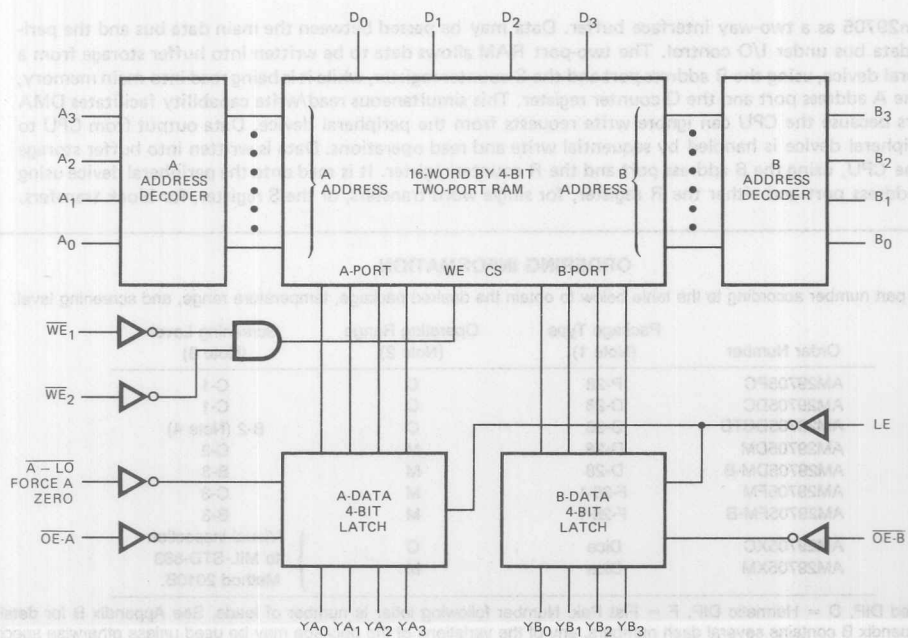
## 16-Word by 4-Bit 2-Port RAM

### ADVANCE INFORMATION

#### DISTINCTIVE CHARACTERISTICS

- **Faster Version of the Am29705**  
The Am29705A has a design objective of a 30-40% speed improvement on the critical paths versus the Am29705.
- **Plug-in Replacement for the Am29705**  
The Am29705A is a pin-for-pin replacement for the Am29705. Systems using the Am29705 will be able to use the Am29705A instead with no design changes.

### LOGIC DIAGRAM



## **Am29720 • Am29721**

Low-Power Schottky 256-Bit Random Access Memories

Refer to  
**Am27LS00 • Am27LS01**  
in the Bipolar Memory Section

**2**

The Am29720 is replaced by the Am27LS01  
(open collector).

The Am29721 is replaced by the Am27LS00  
(3-state).

## **Am29750A • Am29751A**

256-Bit Generic Series Bipolar PROM

Refer to  
**Am27S18 • Am27S19**  
in the Bipolar Memory Section

The Am29750A is replaced by the Am27S18  
(open collector).

The Am29751A is replaced by the Am27S19  
(3-state).

# **Am29760A • Am29761A**

1024-Bit Generic Series Bipolar PROM

Refer to  
**Am27S20 • Am27S21**  
in the Bipolar Memory Section

The Am29760A is replaced by the Am27S20  
(open collector).

The Am29761A is replaced by the Am27S21  
(3-state).

# **Am29770 • Am29771**

2048-Bit Generic Series Bipolar PROM

Refer to  
**Am27S12 • Am27S13**  
in the Bipolar Memory Section

The Am29770 is replaced by the Am27S12  
(open collector).

The Am29771 is replaced by the Am27S13  
(3-state).

# Am29774 • Am29775

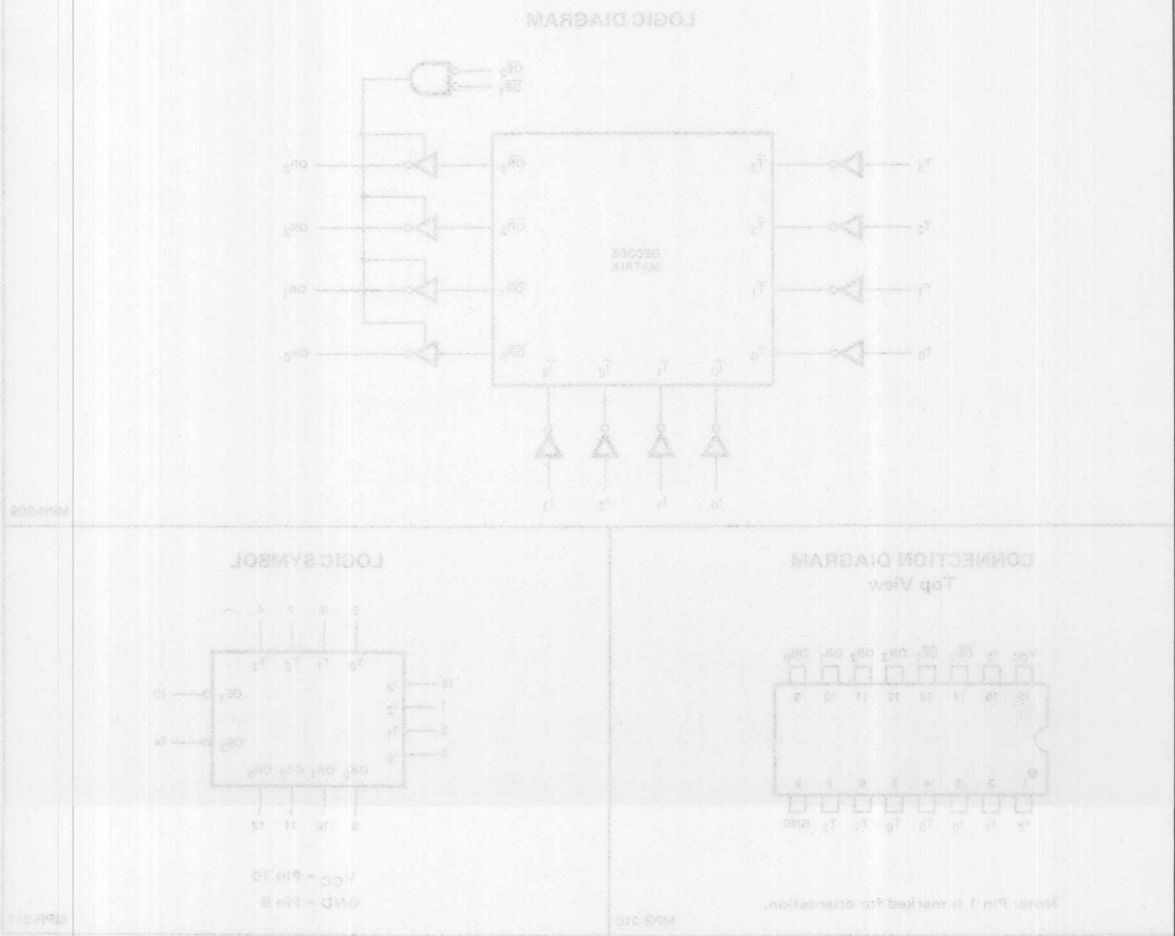
4096-Bit Generic Series Bipolar PROM with Register

Refer to  
**Am27S26 • Am27S27**  
in the Bipolar Memory Section

2

The Am29774 is replaced by the Am27S26  
(open collector).

The Am29775 is replaced by the Am27S27  
(3-state).



## DISTINCTIVE CHARACTERISTICS

- 16 separate instructions — 2, 4, 8, or 16-way branch in one microprogram execution cycle
- Four individual test inputs
- Four individual outputs for driving the four OR inputs on the Am2909 Microprogram Sequencer
- Provides maximum branch capability in a microprogram control unit using the Am2909
- Advanced Low-Power Schottky processing
- 100% reliability assurance testing in compliance with MIL-STD-883

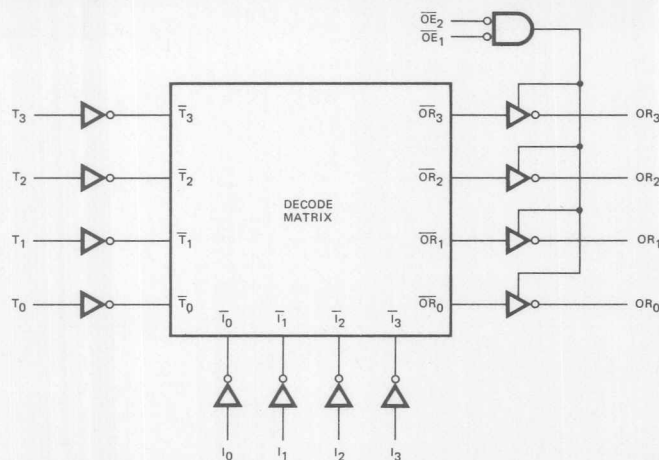
## FUNCTIONAL DESCRIPTION

The Am29803A is a Low-Power Schottky processed device that provides 16-way branch control when used in conjunction with the Am2909 Microprogram Sequencer.

The device features 16 instructions that provide all combinations of simultaneous testing of four different inputs. The device has four outputs that are used to drive the four OR inputs of the Am2909 Microprogram Sequencer.

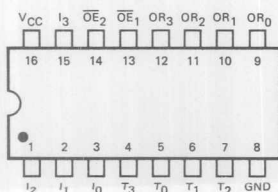
The "zero" instruction inhibits the testing of any of the four test (T) inputs. The remaining 15 instructions are used to test combinations of 1, 2, 3, or 4 of the T inputs simultaneously. If one T input is being tested, the Am29803A will select one of two possible addresses. If two T inputs are being tested, the device will select one of four possible addresses. If three T inputs are being tested, the device will select one of eight possible addresses. If all four T inputs are being tested, the device will select one of sixteen addresses as the field used to drive the OR inputs of the Am2909.

## LOGIC DIAGRAM



MPR-309

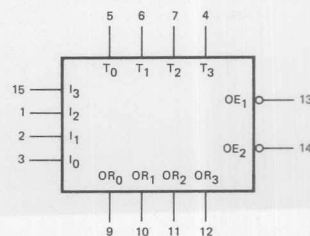
## CONNECTION DIAGRAM Top View



Note: Pin 1 is marked for orientation.

MPR-310

## LOGIC SYMBOL



V<sub>CC</sub> = Pin 16  
GND = Pin 8

MPR-311



**MAXIMUM RATINGS** (Above which the useful life may be impaired)

|   |                                |
|---|--------------------------------|
| Storage Temperature   | -65°C to +150°C                |
| Temperature (Ambient) Under Bias                                | -55°C to +125°C                |
| Supply Voltage to Ground Potential (Pin 16 to Pin 8) Continuous | -0.5V to +7.0V                 |
| DC Voltage Applied to Outputs                                   | -0.5V to +V <sub>CC</sub> max. |
| DC Input Voltage  | -0.5V to +5.5V                 |
| DC Input Current  | -30mA to +5mA                  |

**OPERATING RANGE**

|       |            |                                  |                             |
|-------|------------|----------------------------------|-----------------------------|
| COM'L | Am29803ADC | T <sub>A</sub> = 0°C to +75°C    | V <sub>CC</sub> = 5.0V ±5%  |
| MIL   | Am29803ADM | T <sub>A</sub> = -55°C to +125°C | V <sub>CC</sub> = 5.0V ±10% |

**ELECTRICAL CHARACTERISTICS OVER OPERATING RANGE** (Unless Otherwise Noted)  
**PRELIMINARY DATA**

| Parameters       | Description                  | Test Conditions  | Min. | Typ.<br>(Note 1) | Max.   | Units |
|------------------|------------------------------|--|------|------------------|--------|-------|
| V <sub>OH</sub>  | Output HIGH Voltage          | V <sub>CC</sub> = MIN., I <sub>OH</sub> = -2.0mA<br>V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub> | 2.4  |                  |        | Volts |
| V <sub>OL</sub>  | Output LOW Voltage           | V <sub>CC</sub> = MIN., I <sub>OL</sub> = 16mA<br>V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>   |      |                  | 0.45   | Volts |
| V <sub>IH</sub>  | Input HIGH Level             | Guaranteed input logical HIGH voltage for all inputs   | 2.0  |                  |        | Volts |
| V <sub>IL</sub>  | Input LOW Level              | Guaranteed input logical LOW voltage for all inputs  |      |                  | 0.8    | Volts |
| I <sub>IL</sub>  | Input LOW Current            | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 0.45V  |      | -0.010           | -0.250 | mA    |
| I <sub>IH</sub>  | Input HIGH Current           | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 2.7V   |      |                  | 25     | μA    |
| I <sub>I</sub>   | Input HIGH Current           | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 5.5V   |      |                  | 1.0    | mA    |
| I <sub>SC</sub>  | Output Short Circuit Current | V <sub>CC</sub> = MAX., V <sub>OUT</sub> = 0.0V (Note 2)   | -20  | -40              | -90    | mA    |
| I <sub>CC</sub>  | Power Supply Current         | All inputs = GND<br>V <sub>CC</sub> = MAX.   |      | 95               | 130    | mA    |
| V <sub>I</sub>   | Input Clamp Voltage          | V <sub>CC</sub> = MIN., I <sub>IN</sub> = -18mA  |      |                  | -1.2   | Volts |
| I <sub>CEX</sub> | Output Leakage Current       | V <sub>CC</sub> = MAX.<br>V <sub>CS1</sub> = 2.4V  |      |                  | 40     | μA    |
|                  |                              |  |      |                  | 40     |       |
|                  |                              |  |      |                  | -40    |       |
| C <sub>IN</sub>  | Input Capacitance            | V <sub>IN</sub> = 2.0V @ f = 1 MHz (Note 3)  |      | 4                |        | pF    |
| C <sub>OUT</sub> | Output Capacitance           | V <sub>OUT</sub> = 2.0V @ f = 1 MHz (Note 3)   |      | 8                |        |       |

Note 1. Typical limits are at V<sub>CC</sub> = 5.0V and T<sub>A</sub> = 25°C

2. Not more than one output should be shorted at a time. Duration of the short circuit should not be more than one second.

3. These parameters are not 100% tested, but are periodically sampled.

Am29803A

SWITCHING CHARACTERISTICS

(T<sub>A</sub> = +25°C, V<sub>CC</sub> = 5.0V)

| Parameters       | Description                          | Test Conditions                                    | Min. | Typ. | Max. | Units |
|------------------|--------------------------------------|--|------|------|------|-------|
| t <sub>PLH</sub> | I <sub>i</sub> to OR <sub>i</sub>    | C <sub>L</sub> = 15 pF<br>R <sub>L</sub> = 2.0 kΩ  |      | 25   | 35   | ns    |
| t <sub>PHL</sub> |                                      |  |      |      |      |       |
| t <sub>PLH</sub> | I <sub>i</sub> to OR <sub>i</sub>    |  |      | 25   | 35   | ns    |
| t <sub>PHL</sub> |                                      |  |      |      |      |       |
| t <sub>ZH</sub>  | $\overline{OE}_i$ to OR <sub>i</sub> | C <sub>L</sub> = 5.0 pF<br>R <sub>L</sub> = 2.0 kΩ |      | 15   | 18   | ns    |
| t <sub>ZL</sub>  |                                      |  |      |      |      |       |
| t <sub>HZ</sub>  | $\overline{OE}_i$ to OR <sub>i</sub> |  |      | 15   | 18   | ns    |
| t <sub>LZ</sub>  |                                      |  |      |      |      |       |

SWITCHING CHARACTERISTICS  
OVER OPERATING RANGE

| SWITCHING CHARACTERISTICS<br>OVER OPERATING RANGE |                                      |   | COM'L   |      | MIL   |      |       |
|---|--------------------------------------|---|---|------|---|------|-------|
|   |                                      |   | T <sub>A</sub> = 0°C to +70°C<br>V <sub>CC</sub> = 5.0V ±5% |      | T <sub>A</sub> = -55°C to +125°C<br>V <sub>CC</sub> = 5.0V ±10% |      |       |
| Parameters  | Description                          | Test Conditions                                   | Min.  | Max. | Min.  | Max. | Units |
| t <sub>PLH</sub>                                  | I <sub>i</sub> to OR <sub>i</sub>    | C <sub>L</sub> = 15 pF<br>R <sub>L</sub> = 2.0 kΩ |   | 45   |   | 60   | ns    |
| t <sub>PHL</sub>                                  |                                      |   |   |      |   |      |       |
| t <sub>PLH</sub>                                  | T <sub>i</sub> to OR <sub>i</sub>    |   |   | 45   |   | 60   | ns    |
| t <sub>PHL</sub>                                  |                                      |   |   |      |   |      |       |
| t <sub>ZH</sub>                                   | $\overline{OE}_i$ to OR <sub>i</sub> |   |   | 30   |   | 30   | ns    |
| t <sub>ZL</sub>                                   |                                      |   |   |      |   |      |       |
| t <sub>HZ</sub>                                   | $\overline{OE}_i$ to OR <sub>i</sub> |   |   | 20   |   | 20   | ns    |
| t <sub>LZ</sub>                                   |                                      |   |   |      |   |      |       |

DEFINITION OF FUNCTIONAL TERMS

I<sub>0</sub>, I<sub>1</sub>, I<sub>2</sub>, I<sub>3</sub>

The four instruction inputs to the device

T<sub>0</sub>, T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub>

The four test inputs for the device

OR<sub>0</sub>, OR<sub>1</sub>, OR<sub>2</sub>, OR<sub>3</sub>

The four outputs of the device that are connected to the four OR inputs of the Am2909

$\overline{OE}_1$ ,  $\overline{OE}_2$

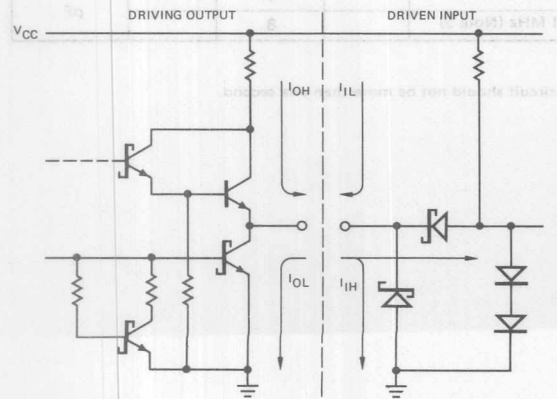
Output Enable. When either  $\overline{OE}$  input is HIGH, the OR<sub>i</sub> outputs are in the high impedance state. When both the  $\overline{OE}_1$  and  $\overline{OE}_2$  inputs are LOW, the OR outputs are enabled and the selected data will be present.

GUARANTEED LOADING RULES  
OVER OPERATING RANGE (In Unit Loads)

A Low-Power Schottky TTL Unit Load is defined as 20μA measured at 2.7V HIGH and -0.36mA measured at 0.4V LOW.

| Pin No.'s | Input/Output      | Input Load | Output LOW |           |
|-----------|-------------------|------------|------------|-----------|
|           |                   |            | HIGH       | MIL COM'L |
| 1         | I <sub>2</sub>    | 0.5        | —          | —         |
| 2         | I <sub>1</sub>    | 0.5        | —          | —         |
| 3         | I <sub>0</sub>    | 0.5        | —          | —         |
| 4         | T <sub>3</sub>    | 0.5        | —          | —         |
| 5         | T <sub>0</sub>    | 0.5        | —          | —         |
| 6         | T <sub>1</sub>    | 0.5        | —          | —         |
| 7         | T <sub>2</sub>    | 0.5        | —          | —         |
| 8         | GND               | —          | —          | —         |
| 9         | OR <sub>0</sub>   | —          | 100        | 44 44     |
| 10        | OR <sub>1</sub>   | —          | 100        | 44 44     |
| 11        | OR <sub>2</sub>   | —          | 100        | 44 44     |
| 12        | OR <sub>3</sub>   | —          | 100        | 44 44     |
| 13        | $\overline{OE}_1$ | 0.5        | —          | —         |
| 14        | $\overline{OE}_2$ | 0.5        | —          | —         |
| 15        | I <sub>3</sub>    | 0.5        | —          | —         |
| 16        | V <sub>CC</sub>   | —          | —          | —         |

LOW-POWER SCHOTTKY INPUT/OUTPUT  
CURRENT INTERFACE CONDITIONS



Note: Actual current flow direction shown.

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| Test   | L | L | L | L | X | X | X | X | L | L | L | L |
|--|---|---|---|---|---|---|---|---|---|---|---|---|
| Test T <sub>0</sub>  | L | L | L | H | X | X | X | L | L | L | L | H |
| Test T <sub>1</sub>  | L | L | H | L | X | X | L | X | L | L | L | L |
| Test T <sub>0</sub> & T <sub>1</sub>                                   | L | L | H | H | X | X | L | L | L | L | L | L |
| Test T <sub>2</sub>  | L | H | L | L | X | L | X | X | L | L | L | L |
| Test T <sub>0</sub> & T <sub>2</sub>                                   | L | H | L | H | X | L | X | L | L | L | L | L |
| Test T <sub>1</sub> & T <sub>2</sub>                                   | L | H | H | L | X | X | L | X | L | L | L | L |
| Test T <sub>0</sub> , T <sub>1</sub> & T <sub>2</sub>                  | L | H | H | H | X | L | L | L | L | L | L | L |
| Test T <sub>3</sub>  | H | L | L | L | L | X | X | X | L | L | L | L |
| Test T <sub>0</sub> & T <sub>3</sub>                                   | H | L | L | H | L | X | X | L | L | L | L | L |
| Test T <sub>1</sub> & T <sub>3</sub>                                   | H | L | H | L | L | X | L | X | L | L | L | L |
| Test T <sub>0</sub> , T <sub>1</sub> & T <sub>3</sub>                  | H | L | H | H | L | X | L | L | L | L | L | L |
| Test T <sub>2</sub> & T <sub>3</sub>                                   | H | H | L | L | L | L | X | X | L | L | L | L |
| Test T <sub>0</sub> , T <sub>2</sub> & T <sub>3</sub>                  | H | H | L | H | L | L | X | L | L | L | L | L |
| Test T <sub>1</sub> , T <sub>2</sub> & T <sub>3</sub>                  | H | H | H | L | L | L | L | X | L | L | L | L |
| Test T <sub>0</sub> , T <sub>1</sub> , T <sub>2</sub> & T <sub>3</sub> | H | H | H | H | L | L | L | L | L | L | L | L |

L = LOW, H = HIGH, X = Don't care

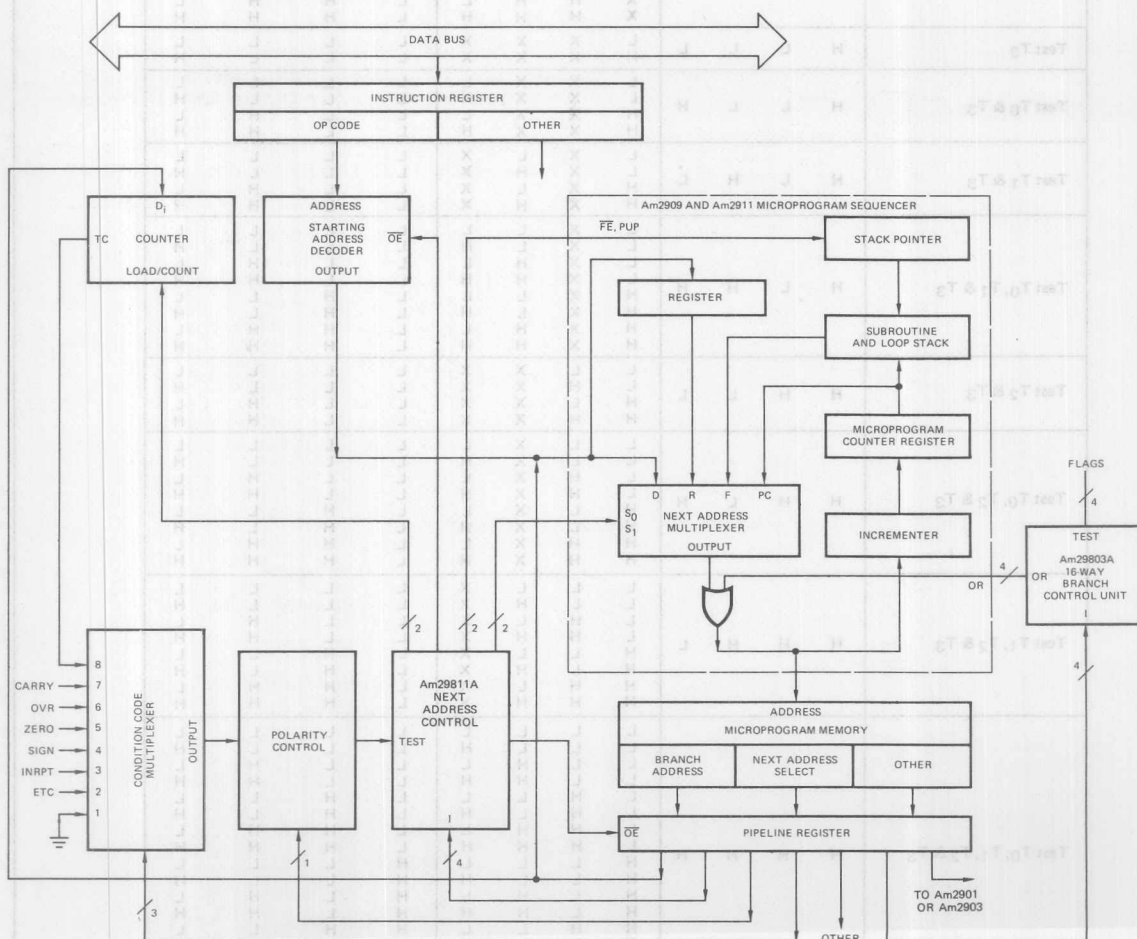
## ORDERING INFORMATION

Order the part number according to the table below to obtain the desired package, temperature range, and screening level.

| Order Number | Package Type (Note 1) | Operating Range (Note 2) | Screening Level (Note 3) |
|--------------|-----------------------|--------------------------|--------------------------|
| AM29803APC   | P-16                  | C                        | C-1                      |
| AM29803ADC   | D-16                  | C                        | C-1                      |
| AM29803ADC-B | D-16                  | C                        | B-1                      |
| AM29803ADM   | D-16                  | M                        | C-3                      |
| AM29803ADM-B | D-16                  | M                        | B-3                      |
| AM29803AFM   | F-16                  | M                        | C-3                      |
| AM29803AFM-B | F-16                  | M                        | B-3                      |

- Notes: 1. P = Molded DIP, D = Hermetic DIP, F = Flat Pak. Number following letter is number of leads. See Appendix B for detailed outline. Where Appendix B contains several dash numbers, any of the variations of the package may be used unless otherwise specified.
2. C = 0°C to +70°C,  $V_{CC} = 4.75V$  to 5.25V, M = -55°C to +125°C,  $V_{CC} = 4.50V$  to 5.50V.
3. See Appendix A for details of screening. Levels C-1 and C-3 conform to MIL-STD-883, Class C. Level B-3 conforms to MIL-STD-883, Class B.

## APPLICATION



A typical computer control unit using the Am2909, Am2911, Am29803A and Am29811A. Note that the least significant microprogram sequencer is an Am2909 and the more significant sequencers are Am2911's.

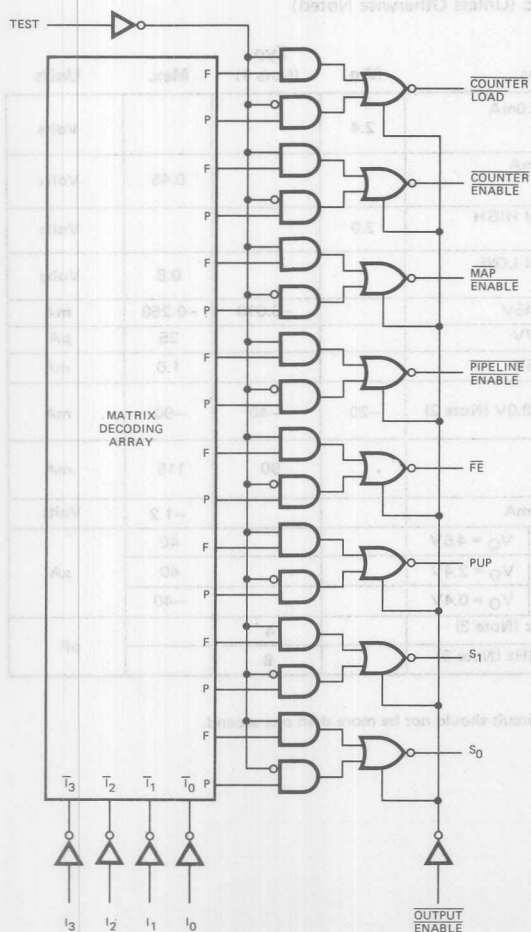
# Am29811A

## Next Address Control Unit

### DISTINCTIVE CHARACTERISTICS

- Next address control unit for the Am2911 Microprogram Sequencer
- 16 next address instructions
- Test input for conditional instructions
- Separate outputs to control the Am2911, an independent event counter, and a mapping PROM/branch address interface
- Advanced Low-Power Schottky technology
- 100% reliability assurance testing in compliance with MIL-STD-883

### LOGIC DIAGRAM



P = Pass  
F = Fail

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### FUNCTIONAL CHARACTERISTICS

The Am29811A is a Low-Power Schottky device designed specifically for next address control of the Am2911 Microprogram Sequencer. The device contains all outputs required to control a high-performance computer control unit or a structured state machine design using microprogramming techniques.

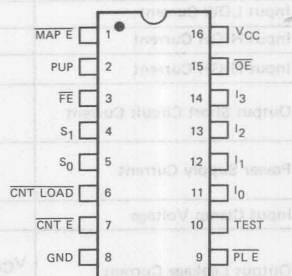
Sixteen instructions are available by using a four-bit instruction field  $I_{0-3}$ . In addition, a test input is available such that conditional instructions can be performed based on a condition code test input.

The full instruction set consists of such functions as conditional jumps, conditional jump-to-subroutine, conditional return-from-subroutine, conditional repeat loops, conditional branch to starting address, and so forth.

One Am29811A can be used to control any number of Am2911 Microprogram Sequencers. The Am2911 Sequencer is a four-bit slice itself. Thus, one Am29811A Next Address Control Unit and three Am2911 Microprogram Sequencers can be used to build the most powerful, state-of-the-art, microprogram sequencer capable of controlling 4k words of microprogram memory.

### CONNECTION DIAGRAM

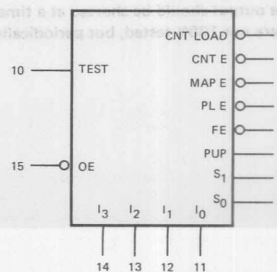
#### Top View



Note: Pin 1 is marked for orientation.

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### LOGIC SYMBOL



$V_{CC}$  = Pin 16  
GND = Pin 8

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# Am29811A

## MAXIMUM RATINGS (Above which the useful life may be impaired)

|   |                                |
|---|--------------------------------|
| Storage Temperature   | -65°C to +150°C                |
| Temperature (Ambient) Under Bias                                | -55°C to +125°C                |
| Supply Voltage to Ground Potential (Pin 16 to Pin 8) Continuous | -0.5V to +7.0V                 |
| DC Voltage Applied to Outputs                                   | -0.5V to +V <sub>CC</sub> max. |
| DC Input Voltage  | -0.5V to +5.5V                 |
| DC Input Current  | -30mA to +5mA                  |

## OPERATING RANGE

|       |            |                                  |                             |
|-------|------------|----------------------------------|-----------------------------|
| COM'L | Am29811ADC | T <sub>A</sub> = 0°C to +75°C    | V <sub>CC</sub> = 5.0V ±5%  |
| MIL   | Am29811ADM | T <sub>A</sub> = -55°C to +125°C | V <sub>CC</sub> = 5.0V ±10% |

## ELECTRICAL CHARACTERISTICS OVER OPERATING RANGE (Unless Otherwise Noted)

### PRELIMINARY DATA

| Parameters       | Description                  | Test Conditions  | Min. | Typ.<br>(Note 1) | Max.   | Units |
|------------------|------------------------------|--|------|------------------|--------|-------|
| V <sub>OH</sub>  | Output HIGH Voltage          | V <sub>CC</sub> = MIN., I <sub>OH</sub> = -2.0mA<br>V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub> | 2.4  |                  |        | Volts |
| V <sub>OL</sub>  | Output LOW Voltage           | V <sub>CC</sub> = MIN., I <sub>OL</sub> = 16mA<br>V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>   |      |                  | 0.45   | Volts |
| V <sub>IH</sub>  | Input HIGH Level             | Guaranteed input logical HIGH voltage for all inputs   | 2.0  |                  |        | Volts |
| V <sub>IL</sub>  | Input LOW Level              | Guaranteed input logical LOW voltage for all inputs  |      |                  | 0.8    | Volts |
| I <sub>IL</sub>  | Input LOW Current            | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 0.45V  |      | -0.010           | -0.250 | mA    |
| I <sub>IH</sub>  | Input HIGH Current           | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 2.7V   |      |                  | 25     | μA    |
| I <sub>I</sub>   | Input HIGH Current           | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 5.5V   |      |                  | 1.0    | mA    |
| I <sub>SC</sub>  | Output Short Circuit Current | V <sub>CC</sub> = MAX., V <sub>OUT</sub> = 0.0V (Note 2)   | -20  | -40              | -90    | mA    |
| I <sub>CC</sub>  | Power Supply Current         | All inputs = GND<br>V <sub>CC</sub> = MAX.   |      | 90               | 115    | mA    |
| V <sub>I</sub>   | Input Clamp Voltage          | V <sub>CC</sub> = MIN., I <sub>IN</sub> = -18mA  |      |                  | -1.2   | Volts |
| I <sub>CEX</sub> | Output Leakage Current       | V <sub>CC</sub> = MAX.<br>V <sub>CS</sub> = 2.4V   |      |                  | 40     | μA    |
|                  |                              |  |      |                  | 40     |       |
|                  |                              |  |      |                  | -40    |       |
| C <sub>IN</sub>  | Input Capacitance            | V <sub>IN</sub> = 2.0V @ f = 1 MHz (Note 3)  |      | 4                |        | pF    |
| C <sub>OUT</sub> | Output Capacitance           | V <sub>OUT</sub> = 2.0V @ f = 1 MHz (Note 3)   |      | 8                |        |       |

Notes: 1. Typical limits are at V<sub>CC</sub> = 5.0V and T<sub>A</sub> = 25°C.

2. Not more than one output should be shorted at a time. Duration of the short circuit should not be more than one second.

3. These parameters are not 100% tested, but periodically sampled.

## SWITCHING CHARACTERISTICS

(T<sub>A</sub> = +25°C, V<sub>CC</sub> = 5.0V)

| Parameters       | Description                          | Test Conditions                                  | Min. | Typ. | Max. | Units |
|------------------|--------------------------------------|--|------|------|------|-------|
| t <sub>PLH</sub> | I <sub>i</sub> to Any Output         | C <sub>L</sub> = 15pF<br>R <sub>L</sub> = 2.0kΩ  |      | 25   | 35   | ns    |
| t <sub>PHL</sub> |                                      |  |      |      |      |       |
| t <sub>PLH</sub> | Test to Any Output                   |  |      | 25   | 35   | ns    |
| t <sub>PHL</sub> |                                      |  |      |      |      |       |
| t <sub>ZH</sub>  | $\overline{\text{OE}}$ to Any Output |  |      | 15   | 20   | ns    |
| t <sub>ZL</sub>  |                                      |  |      |      |      |       |
| t <sub>HZ</sub>  | $\overline{\text{OE}}$ to Any Output | C <sub>L</sub> = 5.0pF<br>R <sub>L</sub> = 2.0kΩ |      | 15   | 20   | ns    |
| t <sub>LZ</sub>  |                                      |  |      |      |      |       |

2

SWITCHING CHARACTERISTICS  
OVER OPERATING RANGE

| SWITCHING CHARACTERISTICS<br>OVER OPERATING RANGE |                                      |  | COM'L   |      | MIL   |      | Units |
|---|--------------------------------------|--|---|------|---|------|-------|
| Parameters  | Description                          | Test Conditions                                  | T <sub>A</sub> = 0°C to +70°C<br>V <sub>CC</sub> = 5.0V ±5% |      | T <sub>A</sub> = -55°C to +125°C<br>V <sub>CC</sub> = 5.0V ±10% |      |       |
|   |                                      |  | Min.  | Max. | Min.  | Max. |       |
| t <sub>PLH</sub>                                  | I <sub>I</sub> to Any Output         | C <sub>L</sub> = 15pF<br>R <sub>L</sub> = 2.0 kΩ |   | 40   |   | 50   | ns    |
| t <sub>PHL</sub>                                  |                                      |  |   |      |   |      |       |
| t <sub>PLH</sub>                                  | Test to Any Output                   |  |   | 40   |   | 50   | ns    |
| t <sub>PHL</sub>                                  |                                      |  |   |      |   |      |       |
| t <sub>ZH</sub>                                   | $\overline{\text{OE}}$ to Any Output |  |   | 25   |   | 30   | ns    |
| t <sub>ZL</sub>                                   |                                      |  |   |      |   |      |       |
| t <sub>HZ</sub>                                   | $\overline{\text{OE}}$ to Any Output |  |   | 25   |   | 30   | ns    |
| t <sub>LZ</sub>                                   |                                      |  |   |      |   |      |       |

## DEFINITION OF FUNCTIONAL TERMS

I<sub>0</sub>, I<sub>1</sub>, I<sub>2</sub>, I<sub>3</sub> The four instruction inputs to the Am29811A.

## TEST

The condition code input to the device. When the test input is LOW, the device assumes the test has failed. When the test input is HIGH, the device assumes the condition code required has been met; the test has passed.

## Counter Load

This output is used to drive the parallel load input of an Am25LS169 up/down counter.

## Counter Enable

This output is used to drive the counter enable input of an Am25LS169 up/down counter.

## Map Enable

This output is used to control the three-state outputs of the mapping PROM or PLA used to provide the initial starting address for each machine instruction.

## Pipeline Enable

This output is used to control the three-state output of the pipeline register (Am2918) containing the branch address for the computer control unit.

## FE File Enable

This output is used to drive the file enable input of the Am2911. When the file enable output is LOW, a stack operation will take place.

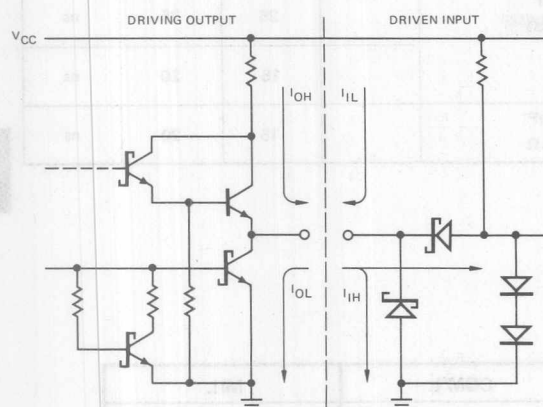
## PUP

Push/Pop. The PUP output is used to drive the push/pop input of the Am2911 Microprogram Sequencer. When the PUP output is HIGH, a push will take place when the file is enabled. When the PUP output is LOW, a pop will take place when the file is enabled.

S<sub>0</sub>, S<sub>1</sub>

These two outputs are used to drive the S<sub>0</sub> and S<sub>1</sub> inputs to the Am2911 Microprogram Sequencer. These outputs control whether the direct input, the register, the microprogram counter, or the stack is selected as the source of the next address for the microprogram memory.

# LOW-POWER SCHOTTKY INPUT/OUTPUT CURRENT INTERFACE CONDITIONS



Note: Actual current flow direction shown.

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# GUARANTEED LOADING RULES OVER OPERATING RANGE (In Unit Loads)

A Low-Power Schottky TTL Unit Load is defined as 20 $\mu$ A measured at 2.7V HIGH and -0.36mA measured at 0.4V LOW.

| Pin No.'s | Input/Output          | Input Load | Output LOW |           |
|-----------|-----------------------|------------|------------|-----------|
|           |                       |            | HIGH       | MIL COM'L |
| 1         | MAP E                 | —          | 100        | 44        |
| 2         | PUP                   | —          | 100        | 44        |
| 3         | $\overline{FE}$       | —          | 100        | 44        |
| 4         | S <sub>1</sub>        | —          | 100        | 44        |
| 5         | S <sub>0</sub>        | —          | 100        | 44        |
| 6         | $\overline{CNT}$ LOAD | —          | 100        | 44        |
| 7         | $\overline{CNT}$ E    | —          | 100        | 44        |
| 8         | GND                   | —          | —          | —         |
| 9         | PL E                  | —          | 100        | 44        |
| 10        | TEST                  | 0.5        | —          | —         |
| 11        | I <sub>0</sub>        | 0.5        | —          | —         |
| 12        | I <sub>1</sub>        | 0.5        | —          | —         |
| 13        | I <sub>2</sub>        | 0.5        | —          | —         |
| 14        | I <sub>3</sub>        | 0.5        | —          | —         |
| 15        | OE                    | —          | 100        | 44        |
| 16        | V <sub>CC</sub>       | —          | —          | —         |

# INSTRUCTION TABLE

| MNEMONIC | I <sub>3</sub> I <sub>2</sub> I <sub>1</sub> I <sub>0</sub> | INSTRUCTION  |
|----------|---|--|
| JZ       | L L L L   | Jump to Address Zero   |
| CJS      | L L L H   | Conditional Jump-to-Subroutine with Jump Address in Pipeline Register.                                       |
| JMAP     | L L H L   | Jump to Address at Mapping PROM Output.  |
| CJP      | L L H H   | Conditional Jump to Address in Pipeline Register   |
| PUSH     | L H L L   | Push Stack and Conditionally Load Counter  |
| JSRP     | L H L H   | Jump-to-Subroutine with Starting Address Conditionally Selected from Am2911 R-Register or Pipeline Register. |
| CJV      | L H H L   | Conditional Jump to Vector Address.  |
| JRP      | L H H H   | Jump to Address Conditionally Selected from Am2911 R-Register or Pipeline Register.                          |
| RFCT     | H L L L   | Repeat Loop if Counter is not Equal to Zero.   |
| RPCT     | H L L H   | Repeat Pipeline Address if Counter is not Equal to Zero.   |
| CRTN     | H L H L   | Conditional Return-from-Subroutine.  |
| CJPP     | H L H H   | Conditional Jump to Pipeline Address and Pop Stack.  |
| LDCT     | H H L L   | Load Counter and Continue.   |
| LOOP     | H H L H   | Test End of Loop.  |
| CONT     | H H H L   | Continue to Next Address.  |
| JP       | H H H H   | Jump to Pipeline Register Address.   |

FUNCTION TABLE

| MNEMONIC | INPUTS   |                       |                     | TEST INPUT | OUTPUTS |         |       |      |  |
|----------|--|-----------------------|---------------------|------------|---------|---------|-------|------|--|
|          | INSTRUCTION<br>I <sub>3</sub> I <sub>2</sub> I <sub>1</sub> I <sub>0</sub> | FUNCTION              | NEXT ADDR<br>SOURCE |            | FILE    | COUNTER | MAP-E | PL-E |  |
| JZ       | L L L L  | JUMP ZERO             | X                   | D          | HOLD    | L L*    | H     | L    |  |
| CJS      | L L L H  | COND JSB PL           | L                   | PC         | HOLD    | HOLD    | H     | L    |  |
|          |  |                       | H                   | D          | PUSH    | HOLD    | H     | L    |  |
| JMAP     | L L H L  | JUMP MAP              | X                   | D          | HOLD    | HOLD    | L     | H    |  |
| CJP      | L L H H  | COND JUMP PL          | L                   | PC         | HOLD    | HOLD    | H     | L    |  |
|          |  |                       | H                   | D          | HOLD    | HOLD    | H     | L    |  |
| PUSH     | L H L L  | PUSH/COND LD CNTR     | L                   | PC         | PUSH    | HOLD    | H     | L    |  |
|          |  |                       | H                   | PC         | PUSH    | LOAD    | H     | L    |  |
| JSRP     | L H L H  | COND JSB R/PL         | L                   | R          | PUSH    | HOLD    | H     | L    |  |
|          |  |                       | H                   | D          | PUSH    | HOLD    | H     | L    |  |
| CJV      | L H H L  | COND JUMP VECTOR      | L                   | PC         | HOLD    | HOLD    | H     | H    |  |
|          |  |                       | H                   | D          | HOLD    | HOLD    | H     | H    |  |
| JRP      | L H H H  | COND JUMP R/PL        | L                   | R          | HOLD    | HOLD    | H     | L    |  |
|          |  |                       | H                   | D          | HOLD    | HOLD    | H     | L    |  |
| RFCT     | H L L L  | REPEAT LOOP, CNTR ≠ 0 | L                   | F          | HOLD    | DEC     | H     | L    |  |
|          |  |                       | H                   | PC         | POP     | HOLD    | H     | L    |  |
| RPCT     | H L L H  | REPEAT PL, CNTR ≠ 0   | L                   | D          | HOLD    | DEC     | H     | L    |  |
|          |  |                       | H                   | PC         | HOLD    | HOLD    | H     | L    |  |
| CRTN     | H L H L  | COND RTN              | L                   | PC         | HOLD    | HOLD    | H     | L    |  |
|          |  |                       | H                   | F          | POP     | HOLD    | H     | L    |  |
| CJPP     | H L H H  | COND JUMP PL & POP    | L                   | PC         | HOLD    | HOLD    | H     | L    |  |
|          |  |                       | H                   | D          | POP     | HOLD    | H     | L    |  |
| LDCT     | H H L L  | LOAD CNTR & CONTINUE  | X                   | PC         | HOLD    | LOAD    | H     | L    |  |
| LOOP     | H H L H  | TEST END LOOP         | L                   | F          | HOLD    | HOLD    | H     | L    |  |
|          |  |                       | H                   | PC         | POP     | HOLD    | H     | L    |  |
| CONT     | H H H L  | CONTINUE              | X                   | PC         | HOLD    | HOLD    | H     | L    |  |
| JP       | H H H H  | JUMP PL               | X                   | D          | HOLD    | HOLD    | H     | L    |  |

L = LOW

DEC = Decrement

H = HIGH

\*LL = Special Case

X = Don't Care

TRUTH TABLE

| MNEMONIC | FUNCTION             | INPUTS         |                |                |                |      | OUTPUTS   |            |     |         |    |       |      |   |
|----------|----------------------|----------------|----------------|----------------|----------------|------|---|------------|-----|---------|----|-------|------|---|
|          |                      | I <sub>3</sub> | I <sub>2</sub> | I <sub>1</sub> | I <sub>0</sub> | TEST | NEXT<br>ADDR<br>SOURCE<br>S <sub>1</sub> S <sub>0</sub> | FILE<br>EE | PUP | COUNTER |    | MAP-E | PL-E |   |
|          |                      |                |                |                |                |      |   |            |     | LOAD    | EN |       |      |   |
|          | PIN NO.              | 14             | 13             | 12             | 11             | 10   | 4   | 5          | 3   | 2       | 6  | 7     | 1    | 9 |
| JZ       | JUMP ZERO            | L              | L              | L              | L              | L    | H   | H          | H   | H       | L  | L     | H    | L |
|          |                      | L              | L              | L              | L              | H    | H   | H          | H   | H       | L  | L     | H    | L |
| CJS      | COND JSB PL          | L              | L              | L              | H              | L    | L   | L          | H   | H       | H  | H     | H    | L |
|          |                      | L              | L              | L              | H              | H    | H   | H          | L   | H       | H  | H     | H    | L |
| JMAP     | JUMP MAP             | L              | L              | H              | L              | L    | H   | H          | H   | H       | H  | H     | L    | H |
|          |                      | L              | L              | H              | L              | H    | H   | H          | H   | H       | H  | H     | L    | H |
| CJP      | COND JUMP PL         | L              | L              | H              | H              | L    | L   | L          | H   | H       | H  | H     | H    | L |
|          |                      | L              | L              | H              | H              | H    | H   | H          | H   | H       | H  | H     | H    | L |
| PUSH     | PUSH/COND LD CNTR    | L              | H              | L              | L              | L    | L   | L          | L   | H       | H  | H     | H    | L |
|          |                      | L              | H              | L              | L              | H    | L   | L          | L   | H       | L  | H     | H    | L |
| JSRP     | COND JSB R/PL        | L              | H              | L              | H              | L    | L   | H          | L   | H       | H  | H     | H    | L |
|          |                      | L              | H              | L              | H              | H    | H   | H          | L   | H       | H  | H     | H    | L |
| CJV      | COND JUMP VECTOR     | L              | H              | H              | L              | L    | L   | L          | H   | H       | H  | H     | H    | H |
|          |                      | L              | H              | H              | L              | H    | H   | H          | H   | H       | H  | H     | H    | H |
| JRP      | COND JUMP R/PL       | L              | H              | H              | H              | L    | L   | H          | H   | H       | H  | H     | H    | L |
|          |                      | L              | H              | H              | H              | H    | H   | H          | H   | H       | H  | H     | H    | L |
| RFCT     | REPEAT LOOP, CTR ≠ 0 | H              | L              | L              | L              | L    | H   | L          | H   | L       | H  | L     | H    | L |
|          |                      | H              | L              | L              | L              | H    | L   | L          | L   | L       | H  | H     | H    | L |
| RPCT     | REPEAT PL, CTR ≠ 0   | H              | L              | L              | H              | L    | H   | H          | H   | H       | H  | L     | H    | L |
|          |                      | H              | L              | L              | H              | H    | L   | L          | H   | H       | H  | H     | H    | L |
| CRTN     | COND RTN             | H              | L              | H              | L              | L    | L   | L          | H   | L       | H  | H     | H    | L |
|          |                      | H              | L              | H              | L              | H    | H   | L          | L   | L       | H  | H     | H    | L |
| CJPP     | COND JUMP PL & POP   | H              | L              | H              | H              | L    | L   | L          | H   | L       | H  | H     | H    | L |
|          |                      | H              | L              | H              | H              | H    | H   | H          | L   | L       | H  | H     | H    | L |
| LDCT     | LD CNTR & CONTINUE   | H              | H              | L              | L              | L    | L   | L          | H   | H       | L  | H     | H    | L |
|          |                      | H              | H              | L              | L              | H    | L   | L          | H   | H       | L  | H     | H    | L |
| LOOP     | TEST END LOOP        | H              | H              | L              | H              | L    | H   | L          | H   | L       | H  | H     | H    | L |
|          |                      | H              | H              | L              | H              | H    | L   | L          | L   | L       | H  | H     | H    | L |
| CONT     | CONTINUE             | H              | H              | H              | L              | L    | L   | L          | H   | H       | H  | H     | H    | L |
|          |                      | H              | H              | H              | L              | H    | L   | L          | H   | H       | H  | H     | H    | L |
| JP       | JUMP PL              | H              | H              | H              | H              | L    | H   | H          | H   | H       | H  | H     | H    | L |
|          |                      | H              | H              | H              | H              | H    | H   | H          | H   | H       | H  | H     | H    | L |

L = LOW

H = HIGH

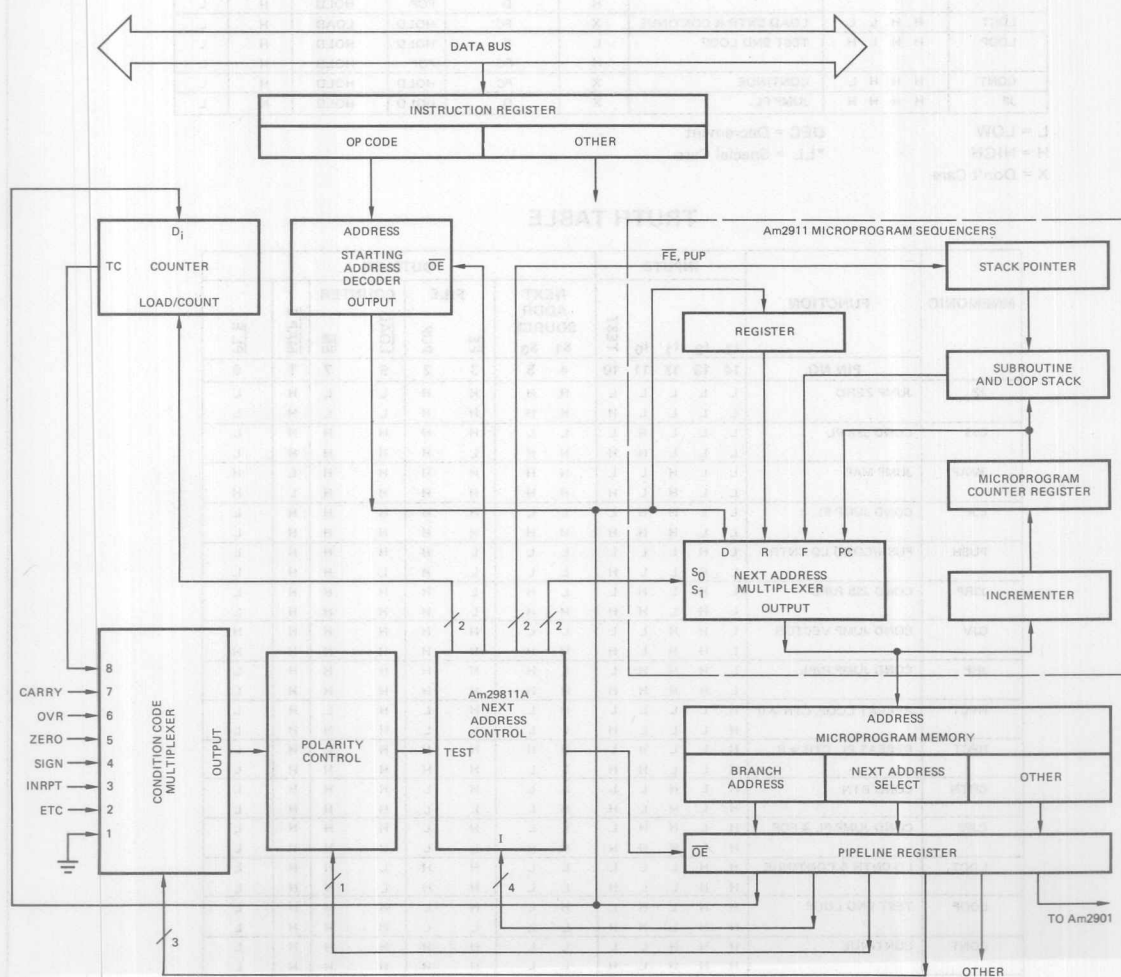
## ORDERING INFORMATION

Order the part number according to the table below to obtain the desired package, temperature range, and screening level.

| Order Number | Package Type (Note 1) | Operating Range (Note 2) | Screening Level (Note 3) |
|--------------|-----------------------|--------------------------|--------------------------|
| AM29811APC   | P-16                  | C                        | C-1                      |
| AM29811ADC   | D-16                  | C                        | C-1                      |
| AM29811ADC-B | D-16                  | C                        | B-1                      |
| AM29811ADM   | D-16                  | M                        | C-3                      |
| AM29811ADM-B | D-16                  | M                        | B-3                      |
| AM29811AFM   | F-16                  | M                        | C-3                      |
| AM29811AFM-B | F-16                  | M                        | B-3                      |

- Notes: 1. P = Molded DIP, D = Hermetic DIP, F = Flat Pak. Number following letter is number of leads. See Appendix B for detailed outline. Where Appendix B contains several dash numbers, any of the variations of the package may be used unless otherwise specified.
2. C = 0°C to +70°C,  $V_{CC} = 4.75V$  to 5.25V, M = -55°C to +125°C,  $V_{CC} = 4.50V$  to 5.50V.
3. See Appendix A for details of screening. Levels C-1 and C-3 conform to MIL-STD-883, Class C. Level B-3 conforms to MIL-STD-883, Class B.

## APPLICATION



A Typical Computer Control Unit Using the Am2911 and Am29811A.



# Am2900 Family Applications Literature

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## Build an Am2900 Microcomputer

This comprehensive book discusses in detail the design of a microprogrammed computer using the 2900 Family. Examples are used extensively. The book's chapters:

- I – Computer Architecture
- II – Microprogrammed Design
- III – The Data Path
- IV – The Data Path, Part Two
- V – Program Control Unit
- VI – Interrupt
- VII – Direct Memory Access
- VIII – The Hex 29
- IX – The Super Sixteen

Order AM-PUB073-X

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## A High Performance Disc Controller

This book covers the detailed design of a controller. Specifically it is an interface between a Pertec disc and a DEC PDP-11® minicomputer. Most controllers will be architecturally similar. Includes schematics and microcode.

Order AM-PUB065      Price \$5.00

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## An Emulation of the Am9080A

This book describes a 2900 based system which executes instructions of the Am9080A MOS microprocessor. It operates about 4 times faster than the Am9080A and leaves space for user defined instructions in addition to the standard instruction set.

Order AM-PUB064      Price \$5.00

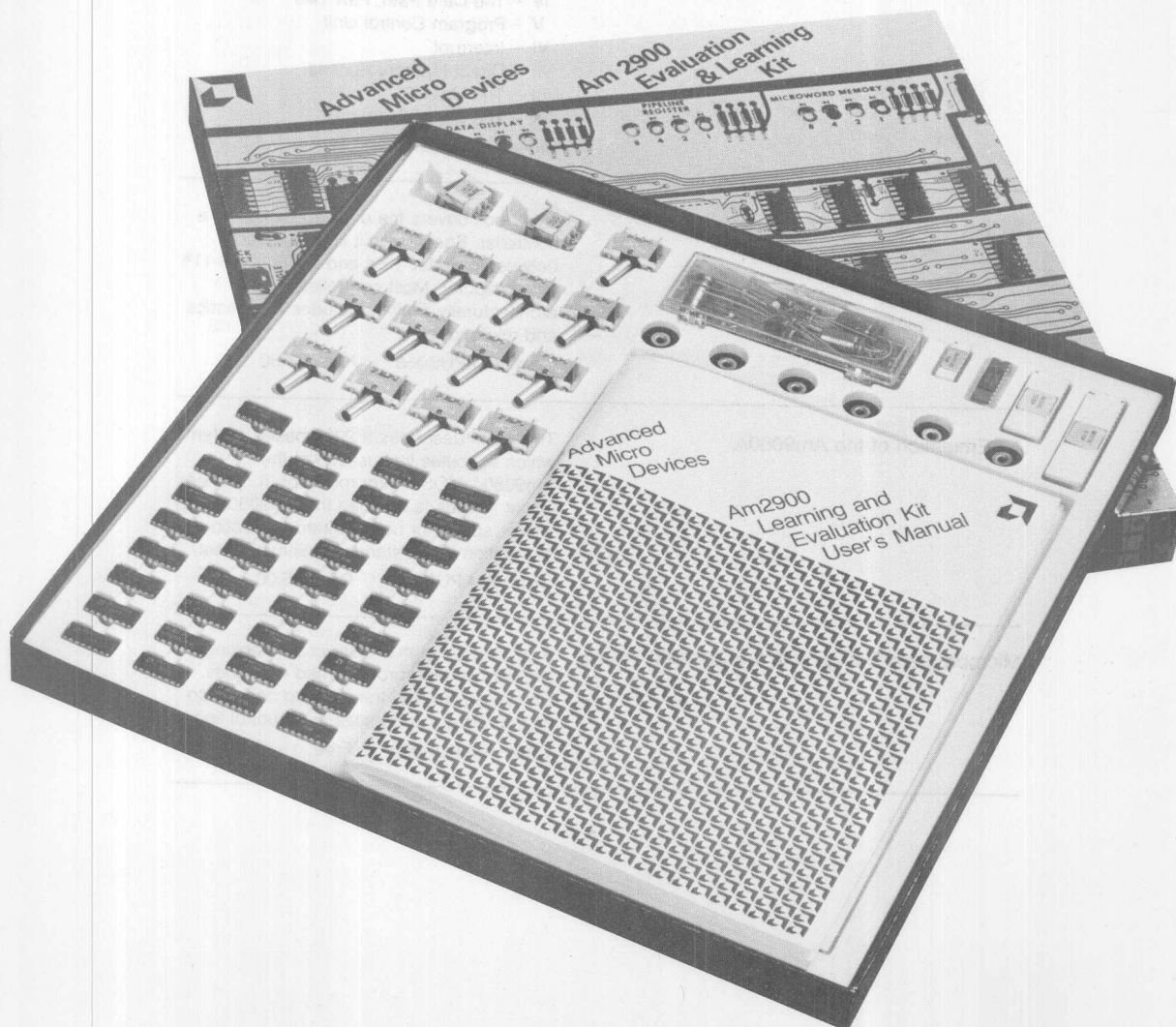
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## Microprogram Design with the Am2900 Family

A discussion of the "instruction-cracking" problem in microprogrammed machines. Discusses ways to translate op codes into microprogram addresses and control lines.

Order AM-PUB069      Free

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### THE Am2900 EVALUATION AND LEARNING KIT

Pictured at the left is the Am2900 Evaluation Kit. The system consists of a microprogrammed control unit which controls all the inputs to an Am2901 microprocessor slice. Thirty-two bit microinstructions are entered into a RAM in the control unit using the switch register. Each microinstruction contains bits to control the Am2901A's A and B addresses, instruction, carry in, and data input. Additional bits in the microinstruction control an Am2909 sequencer which generates the addresses for the microprogram memory. Once entered, microinstructions may be executed using a single step clock or using a pulse generator. The LED display provides access to nearly every signal path in the system.

Sixteen "sequence control" instructions are available, including execute, branch conditional, jump-to-subroutine, return, and loop. Because the set of sequence instructions is implemented in a PROM, the user can devise his own set of operations by programming a new PROM.

The kit is supplied with 40 IC's, all resistors, capacitors, LED's and switches, the PC board, and a manual containing assembly instructions, theory and a set of exercises. The user need only solder the components in place and attach a 5 V power supply (2.0 ampere rating).

Working with the kit, the user will gain familiarity with a high performance pipelined microprogrammed architecture, and with the operation of the Am2909 and Am2901A. By driving the kit from a pulse generator, the user can observe the operation of the components in real time, executing real instructions.

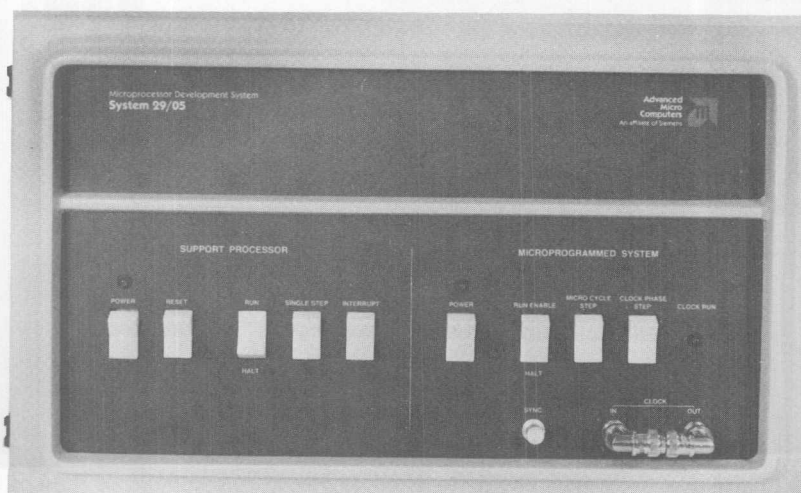
The part number for this kit is Am2900K1.

# System 29

## The Advanced Microprogram Development System

### FEATURES

- **The first universal, complete development system for microprogrammed machines.**  
Use to assemble microcode, debug microcode, check out hardware.
- **AMDASM® 29 microassembler resident on system.**  
Microprograms can be written, assembled, and loaded into the development hardware all on one system. No transferring from one system to another. No messy paper tape.
- **Software to check out microcode.**  
All the tools needed in a useful development system including single step, trap, edit.
- **Writable Control Store up to 4K words.**  
RAM in System 29 serves as control memory for prototype. Expandable up to 4K words, up to 128 bits each. Access time down to 50ns.
- **Application Cards Available.**  
Pre-built prototype systems reduce design time, get products out sooner.
- **Universal Prototyping cards**  
Use popular SBC-80 form factor and hold parts on 0.3", 0.4", and 0.6" centers.
- **Time proven disk operating system.**  
Complete file management including a context editor.
- **8080 software development tools.**



## SOFTWARE FEATURES

- The convenience of the AMDOS® 29 Disk Operating System with a full set of file management commands, including and editor.
- Microprogram generation software including the AMDASM® 29 micro-assembler and the AMSCRM® 29 and AMPROM® 29 post-processing programs.
- Microprogram support software to load, save, and debug microcode during the firmware/hardware check-out phase.
- Am9080A software to write special programs to add to the existing software or for separate designs using the Am9080A fixed-instruction-set micro-processor.

## HARDWARE FEATURES

- Writable Control Store for microprogram memory and ROM simulation. Its storage capacity can be easily expanded and a high speed option permits real-time testing.
- Microcode check-out functions let the user interact freely with the microcode, i.e., display, modify, move, locate, store, and verify. The user can also single-step through instructions, set trap bits, set comparison values, and force address jumps for easy test and debug of the microcode and its associated hardware. These are combined hardware-software features which are accessible either at the CRT Console or the System Mainframe front panel.
- Universal Prototyping Cards feature high packing density. They accept the user prototype and plug right into System 29.
- The Outboard Interface cable interfaces System 29 to the user design for a form factor that calls for an outboard configuration.
- A number of application cards help the user in his microprogrammed system design.
- Developed microcode can be stored on flexible diskettes, printed out, punched on paper tape or used to drive a PROM programmer.
- Diskette to main memory data transfers are affected by direct memory access (DMA) without I/O port addressing. This results in high-speed data transfers.
- An internal 2.457MHz crystal-controlled clock oscillator is provided. An external connector is available for providing a different clock frequency from a signal generator or an external circuit to meet individual user requirements.



### DESCRIPTION:

System 29 is a complete development system. It encompasses all the tools needed, from microcode/firmware definition, assembly, check-out of the hardware and formatting of the microcode, through programming PROM's.

System 29 includes a System Mainframe, CRT Console, and Dual-Drive Flexible Disk. It comes with a comprehensive software package. It is ready to operate in its basic configuration which includes 2K words by 64 bits Writeable Control Store and a Computer Control Unit (CCU) microprogram con-

troller. A number of peripherals (line printer, paper tape reader-punch, PROM programmer) and cards (high-speed Writeable Control Store, trace analyzer, 8080 emulator application card, 16-bit microcomputer application card) enhance its performance even further.

Because it is controlled by an Am9080A, it can also serve as a software development system for the 8080 fixed-instruction-set microprocessors.



## SYSTEM DESCRIPTION

### BASIC SYSTEM:

A complete working system including;

#### Equipment

- System Mainframe:
- Support Processor:
  - Am9080A CPU Card
  - System Memory Card, 32K bytes, expandable to 64K bytes with an additional card
  - 4 Serial Ports (RS232)
  - 1 Parallel Port
  - Power Supply
- Microprogrammed System:
  - 1 Writable Control Store Card, 2K x 64 bits. System is pre-wired for 2.
  - 1 Instrumentation Card
  - 1 Computer Control Unit Application Card
  - 5 Open Slots for Additional User Cards
  - 1 Power Supply, +5V, 25A (50A Optional)

- CRT Console
- Dual Drive Flexible Disk
- Universal Prototyping Card
- Outboard Interface Cable
- Blank Diskettes (2)

#### Software

- AMDOS 29® Disk Operating System with full set of commands
- Microprogram Generation Software
  - AMDASM 29® Microprogram Assembler
  - AMSCRM 29®, AMPROM 29® Post-Processing Programs
- Microprogram Support Software
- Am9080A Software (Assembler, Loader, Dynamic Debugger including disassembler and trace capability)

#### Documentation (2 sets)

- User Manual
- Software Manual
- Hardware Manual

#### Services

- User Training (2 Persons)
- Field Applications Support
- Warranty: 1 Year (90 days on System Mainframe Plug-in Cards)

### SYSTEM OPTIONS<sup>1</sup>

#### CARDS<sup>2</sup>

##### Option No.

- 0100 *Universal Prototyping card*, additional to one included in the basic system.
- 0105 *Writable Control Store card*, 2K x 64 bits, additional to one included in the basic system. Field updatable.
- 0106 *High Speed Writable Control Store card*, 1K x 64 bits; system is pre-wired for 2. Field updatable.

#### PERIPHERALS

- 0503 *Character Printer*, 120 CPS.
- 0510 *Paper Tape Reader-Punch*<sup>3</sup>, 300cps read, 75cps punch.

#### SERVICES

- 0800 *Training Course*. System 29, for one additional person. Training for 2 persons included in the basic system.

#### MISCELLANEOUS

- 0900 *High Speed Extender card*, multilayer (internal ground plane)
- 0901 *Power Supply*, 50A Module. Field updatable
- 0902 *Diskettes*. Package of 10 blanks<sup>4</sup>.
- 0903 *System Manual*. One set of manuals, additional to 2 provided with the basic system.<sup>4</sup>

#### NOTES:

1. SY29XXXX - When coding orders, replace X's with 4 digit option number, leave blank for basic system. Example: SY290500 is code for the Line Printer option.
2. Warranty 90 days, parts and labor.
3. Warranty 120 days, parts and labor.
4. Quantity 2 minimum when purchased separately.

**Why?**

The "microprogrammable" microprocessor—like the Am2900 family—offers higher performance and versatility than the "fixed-instruction-set" microprocessor—like the Am9080 family. However, this versatility makes the design of microprogrammed machines more difficult. To start with, the engineer must design his own set of particular instructions before he can write application software. He also customizes the architecture of his special purpose processor. It is this versatility which optimizes performance and, at the same time, complicates the design process—because every design is different.

Since each design is different, hardware prototyping and microcode development tend to be an ad hoc process with little of the work expended on one design transferable to the next.

Until now, no single tool had been available to assist in the complete development of microprogrammed machines. Before the engineer could even start with his design, he had to locate a computing facility to assemble the microcode, come up with some type of PROM simulator (i.e., a dedicated mini with writable control store), assemble special test fixtures to control the system parameters of a given architecture, develop special programs to manipulate the microcode in the PROM simulator. Then, he had to generate the microcode with a microprogram assembler that probably required modification. All this meant delay and expense.

**Microprogramming had to be made easier.**

**Advanced Micro Computers now offers a cost effective solution with System 29, the Advanced Microprogramming Development System.**

Read about its contribution from the start to finish of your microprogrammed design. Find out how it can significantly reduce your design time and then be used to either follow your new product through production or start immediately on your next design. And how it offers much more than a mere technical solution. Read why it is "an investment that pays for itself."

**FROM:****START****ARCHITECTURE  
DESIGN**

Get a head start with AMC application cards

**FIRMWARE**

Write and generate microcode right at the System 29 console

**HARDWARE  
LOGIC DESIGN**

Load microcode directly into writable control store

**FIRMWARE/HARDWARE  
CHECK-OUT**

A powerful set of programs manipulate the microcode at will and check it with the hardware

**TO:****DESIGN  
COMPLETION****AND****PRODUCTION  
TESTING**

System 29 is a fully documented general-purpose tool. It not only can service several designs but also can function as a manufacturing test facility.

## From firmware generation...

### The convenience of a disk operating system...

Once the microprogrammed design architecture is set, the next step is the generation of the microcode. System 29 provides the tools.

- ☐ The AMDOS® 29 Disk Operating System provides complete file management for a Dual Flexible Disk System.
- ☐ Each flexible disk has **ample storage** (240K bytes) for long programs.
- ☐ A powerful **text editor** is used to create and modify microprogram source files.
- ☐ A number of other **utility programs** makes it easy to manipulate the code from one peripheral format to another, process various commands in batch mode, provide information about any file on the disk, etc....
- ☐ A **CRT Console** lets the user interact with the system. An optional high-speed line printer provides permanent hardcopy which is helpful during the firmware development phase.

### Get a head start with a number of AMC application cards

They work from day one and provide the general-purpose functions that get microprogrammed designs off the ground and let designers concentrate on their specific application. The Computer Control Unit (CCU) is an example.

### You have all the tools for checking your logic design

Sit down and write simple diagnostic programs to verify that prototyping circuits perform the way they are intended to.

### ...And a powerful resident micro-assembler...

Microcode can be written in symbolic language and assembled right on System 29 with AMDASM® 29. AMDASM 29 is a powerful assembler that is easily "personalized" to match the microformat. Its output is readily loadable into the Writable Control Store which is supplied with System 29 to simulate the microprogram PROM's in the user system.

### ...Provide all the software tools for firmware generation.

By writing individual programs for the Support Processor, the designer can add to System 29's already powerful set of commands and customize System 29 for particular needs.

## ...and the integration of both

### Versatile microprogram memory is the key to firmware generation and hardware check-out.

- ☐ **Writable Control Store (WCS)** is where it all happens since it serves the vital function of microprogram memory and ROM simulation. Microprograms can easily be loaded into it after assembly and initial debug. Many features (such as automatic assembly of the modified portion of the microprogram) are available to conveniently manipulate the microcode at any time. The storage capacity can be easily expanded and a high-speed option permits real-time operation of your design.
- ☐ **Microcode Check-Out Functions**—Once the microprogram is assembled, System 29 knows the battle is only half over. Firmware and hardware can be integrated right at the CRT Console.

A powerful set of programs lets the user display, move, locate, store and verify the microcode at will.

Single-step through instructions, set traps, loop around sections of code, execute microcode until a specific address is reached, then execute some special code (i.e., to display the content of some registers).

## ...to hardware design

### Build your microprogrammed system inboard or outboard to System 29

System 29 is accommodating. It has five card slots dedicated to the user, prototype complete with a power supply to drive them. If an outboard configuration is preferred, it allows easy connection to its development functions.

### Take advantage of the universal card format

The Universal Prototyping Card is compatible with the SBC-80 format which is rapidly becoming the industry standard. It offers high packing density and easy interface to both System 29 controls and other circuits. System 29 can host enough cards for any design.

Single Level Trace allows monitoring of 20 test points connected anywhere in the user's prototype.

A Logic Analyzer option allows monitoring of 64 test points in real-time and displays the last 256 states on the CRT Console.

- ☐ **Microcode Output in a Directly Usable Format**—When the microcode is debugged, the System 29 Reader/Punch option will output a paper tape directly usable on most commercially available PROM programmers. Alternatively, an optional PROM programmer can be driven directly from System 29.

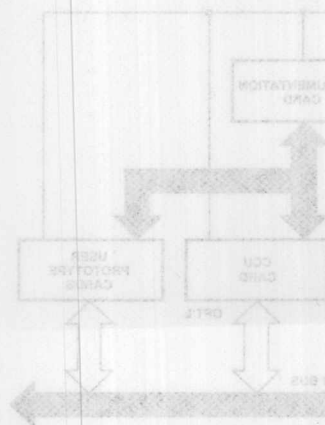
### An 8080 software development capability is also included

Because System 29 is controlled by an Am9080A\* based Support Processor, a complete software package is available to generate programs for other designs with the widely used Am9080A/8080 fixed-instruction-set microprocessor.

The tools include an assembler, a debugger complete with a disassembler, and a loader.

This capability adds to the universality of System 29 and is another factor to justify its use for microprocessor development.

\*The Am9080A is a high-speed, pin-compatible version of the 8080A.





## The hardware

The **System Mainframe** is divided into a Support Processor section and a Microprogrammed System section. The **Support Processor** is a microcomputer built around the Am9080A MOS fixed-instruction-set microprocessor and a 32K RAM System Memory. It controls all input/output communications with the user via the peripherals. It executes programs called from the CRT Console and provides all the necessary controls to the Microprogrammed System.

The **Microprogrammed System** interfaces to microprogrammed designs. It has the ability to house these circuits on a number of Universal Prototyping Cards. It can also interface to outboard designs, located outside the System Mainframe. The Microprogrammed System section also houses the Writable Control Store (WCS) Card(s), the Instrumentation Card, and the Computer Control Unit (CCU) card.

- **Writable Control Store.** The basic WCS configuration is easily expanded, by the addition of a second pre-wired card, from 2K by 64 bits to 4K by 64 bits or 2K by 128 bits. Additional WCS Cards can be accommodated, if necessary. Two optional high-speed WCS Cards (1K by 64 bits each), make it possible to achieve speeds similar to that of final designs.

- **The Instrumentation Card** includes the functions of clock control as well as microprogram address trap and branch control.

Stop, single-step, or run can be activated from commands at the CRT console or buttons at the mainframe front panel.

Stop or breakpoint on an address, or sequence of addresses, input from the keyboard. System 29 will stop the microprogram when the input address matches the microprogram address provided to WCS. Inputting a sequence of addresses, allows isolation of a particular combination of microcode.

Branch or force a particular address onto the microprogram for one microcycle. For example, this allows branching to a special diagnostic subroutine or an alternate microprogram subroutine you may want to activate.

Monitor in real-time some 64 test points (an option to System 29). Define these test points, i.e., the microword, the output of the ALU, the CPU-to-memory bus, designators, etc. They are saved at the clock frequency (or some selectable fraction or multiple of it). When the clock is stopped, some 256 steps can be displayed in a convenient format to help trace what actually happened, step-by-step.

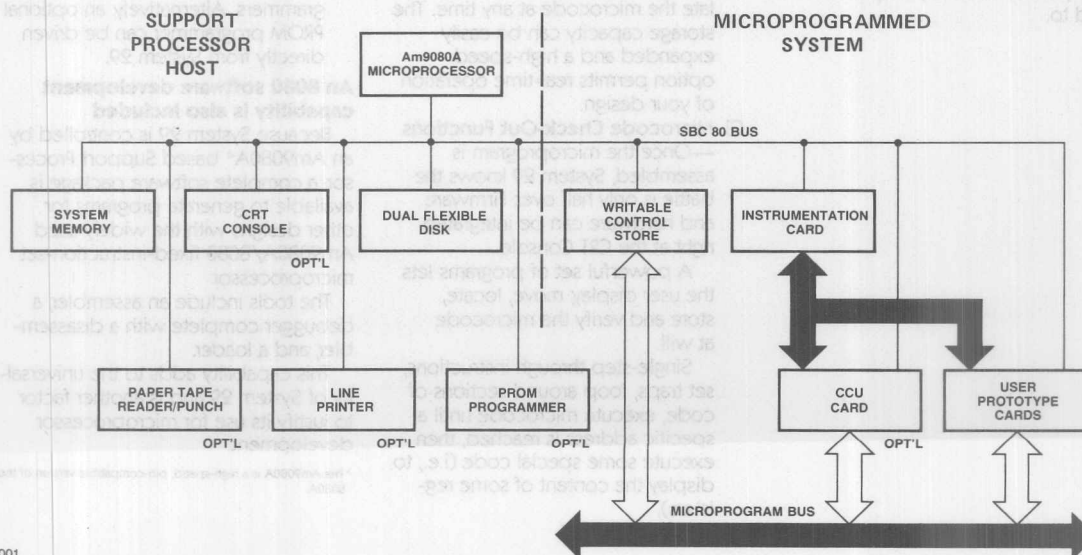
The standard configuration allows the user to monitor in snapshot fashion (stop the clock and interrogate) some 20 test points and up to 12 microprogram address bits.

- **Application Card.** The CCU Card is an application card available from AMC to expand the capabilities of System 29. It is a pipelined microprogram sequencing unit designed around the Am2911 Microprogram Controller.

- **The Universal Prototyping Card** has space for over 100 16-pin DIPs. It holds wire-wrapped dual-in-line sockets with pin centers of 0.3, 0.4, 0.6, 0.7, and 0.9 inches. It is pre-wired for Vcc and ground on each side respectively.

- **Power Supply.** The System Mainframe includes a separate +5 volt, 25 amp (50 amp optional) power supply to support any bipolar circuits mounted on inboard Universal Prototyping Cards. Therefore, a totally self-contained microprogrammed system can be designed.

- **The Peripherals** include a CRT Console and a Dual Flexible Disk for the basic configuration. Optional peripherals include a Line Printer, a Paper Tape Reader/Punch, and a PROM programmer.



AMU-001

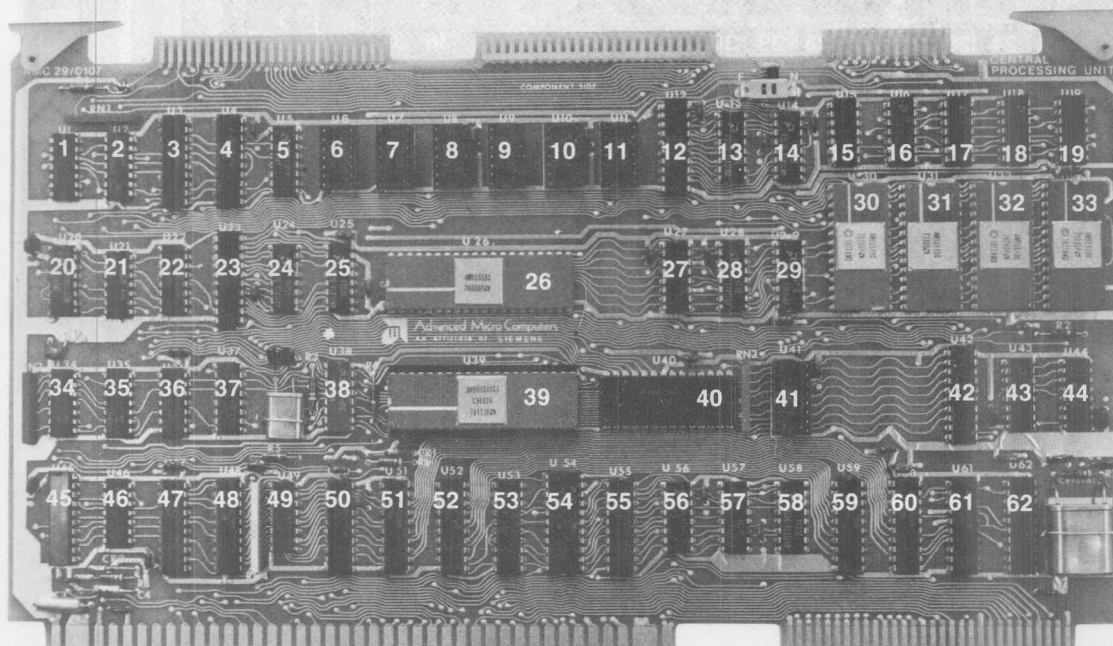


## System 29 LOGIC CARD SET

THE HEART OF SYSTEM 29 IS AMD'S POWERFUL Am9080 MICROCOMPUTER WHICH FEATURES:

- **Am9080 MICROPROCESSOR** ————— Compatible with Intel 8080
- **FOUR SERIAL I/O CHANNELS** ————— 9600, 9600, 600, 110 bauds
- **THREE EIGHT-BIT PARALLEL I/O PORTS** ————— Am9555
- **CRT CONSOLE INTERFACE** ————— RS232 – 9600 baud
- **PAPER TAPE READER/PUNCH INTERFACE** ————— RS232 – 600 baud
- **PROM PROGRAMMER INTERFACE** ————— Data I/O Corp model 17 or 19
- **LINE PRINTER INTERFACE** ————— For hard copies  
RS232 – 9600 baud
- **DUAL DRIVE FLEXIBLE DISK INTERFACE** —————
- **32K X 8 MOS SYSTEM RAM** ————— 500K bytes on-line mass storage  
Expandable up to 64K x 8 for  
higher level languages

3



SUPPORT PROCESSOR SECTION

## System 29 LOGIC CARD SET

### WRITABLE CONTROL STORE

– TO STORE USER MICROCODE UNDER DEVELOPMENT

- HIGH SPEED/BIPOLAR

MAXIMUM SPEED

44nsec TYPICAL

50nsec MAX

1K X 64

4K X 64

2K X 128\*

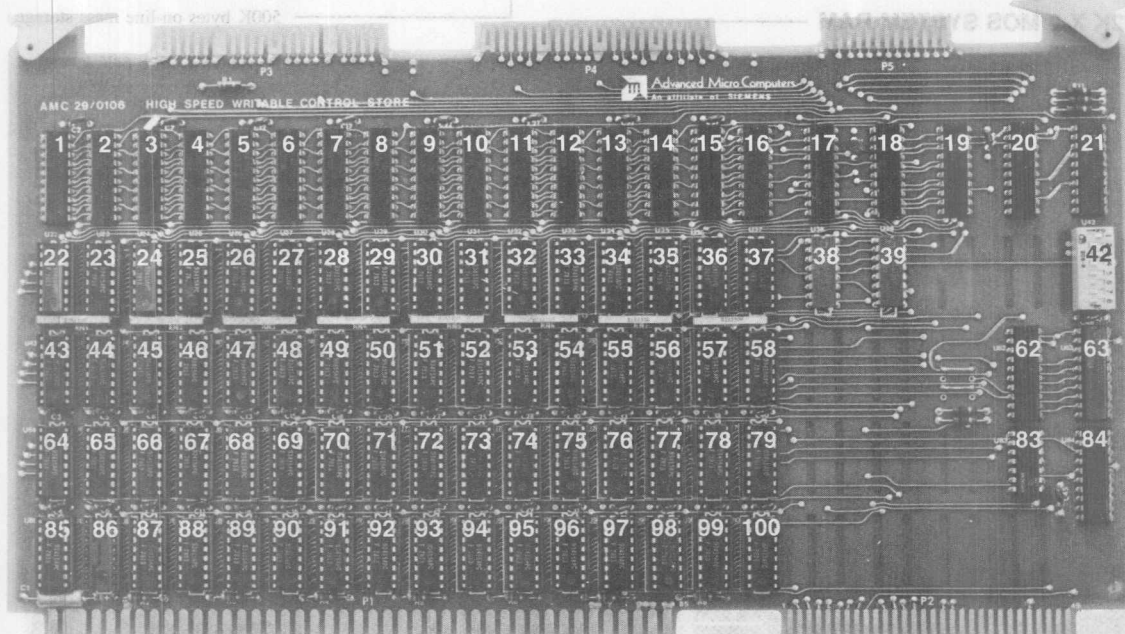
- MEDIUM SPEED

MAXIMUM CAPACITY

2K X 64

4K X 128

MAX  
CONFIG.



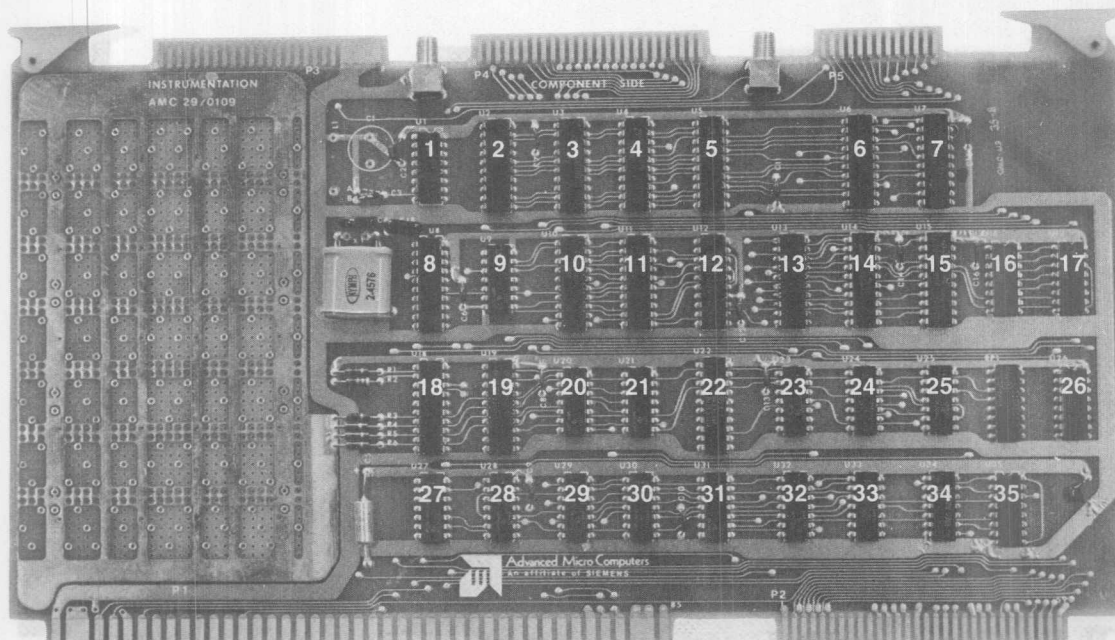
MICROPROGRAMMED SECTION

## System 29 LOGIC CARD SET

### INSTRUMENTATION CARD

CONTAINS ALL THE CIRCUITS TO IMPLEMENT THE  
DEBUGGING FEATURES

- **CLOCK GENERATION FROM OSCILLATOR**
- **CLOCK CONTROL** ————— Control can be entered from front panel or CRT
- **HALT, RUN, SINGLE STEP, MICRO STEP, MULTIPLE MICRO STEP** ————— Single step = one clock cycle  
Micro step = one microinstruction
- **ADDRESS BREAKPOINT/SYNC/INTERRUPT 5**
- **ADDRESS JAMMING** ————— Initiate program execution at selected locations
- **KEEP TRACK OF LAST MICROPROGRAM ADDRESS**
- **KEEP TRACK OF LAST STATE OF 20 MONITOR BITS** ————— Can be interactively displayed at CRT
- **TRAP BITS TO CONTROL CLOCK** ————— Defined by user



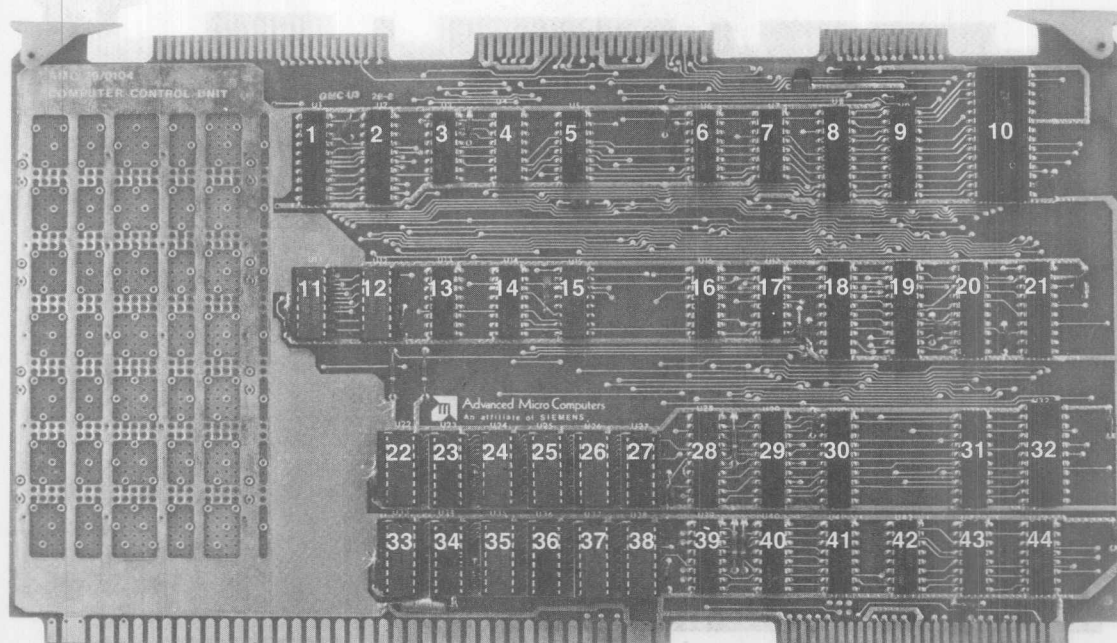
MICROPROGRAMMED SECTION

# COMPUTER CONTROL UNIT CARD

PROVIDES PIPELINED CONTROL FOR ADDRESS SEQUENCING  
AS WELL AS AN OPCODE MAP

## FEATURES:

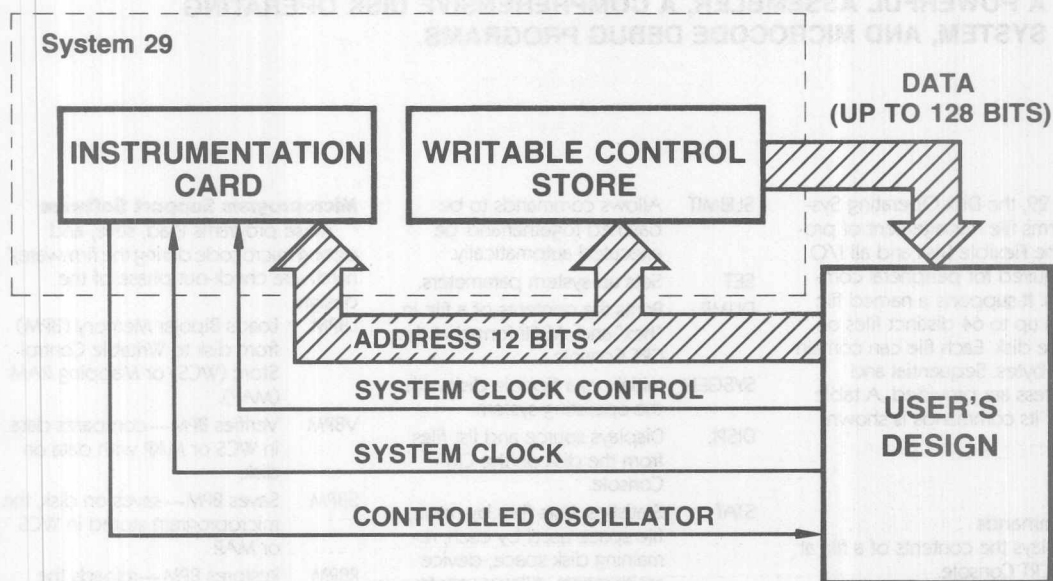
- AN EXAMPLE OF GENERAL PURPOSE MICROPROGRAM  
NEXT ADDRESS CONTROL
- SECTIONS OF PIPELINE REGISTER DEDICATED TO  
PRE-DEFINED MICROCODE FORMAT
- INTERFACE DIRECTLY TO WCS
- OPTIONAL USE BY USER
- SIMILAR TO Am2910
- STARTING ADDRESS MAPPING RAM (256 WORDS X 12 BITS) ——— RAM can be modified easily  
interactively at CRT
- VECTOR ADDRESS PROM ——— For interrupts
- ADDRESSES 4K WORDS OF MICROCODE WITH THREE SEQUENCERS ——— One of 16 conditions can be  
selected for a conditional  
instruction
- NEXT ADDRESS CONTROLLER
- TEST CONDITION MULTIPLEXER
- 16-WAY BRANCH CONTROL
- LOOP COUNTERS



MICROPROGRAMMED SECTION



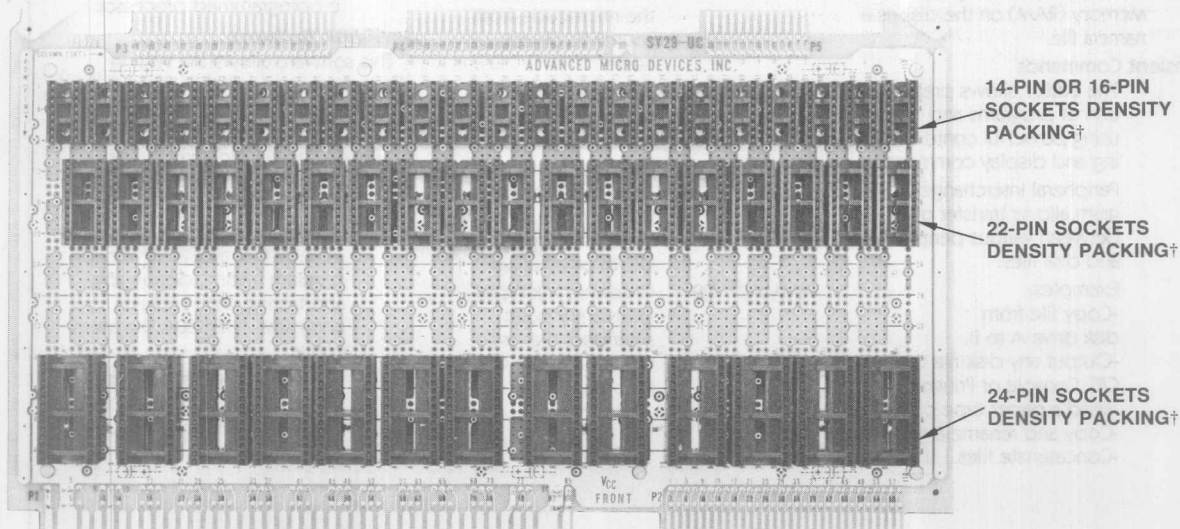
## System 29 LOGIC CARD SET



Extremely simple user interface. Address bus,  
Data bus, and a few control lines and clock signals.

AMC-008

### USER INTERFACE



### UNIVERSAL PROTOTYPE CARD

†SOCKETS ARE NOT INCLUDED



## System 29 SOFTWARE

**A COMPLETE SOFTWARE PACKAGE COMES WITH SYSTEM 29, INCLUDING A POWERFUL ASSEMBLER, A COMPREHENSIVE DISK OPERATING SYSTEM, AND MICROCODE DEBUG PROGRAMS.**

AMDOS 29, the Disk Operating System, performs file management of programs on the Flexible Disk and all I/O routines required for peripheral communications. It supports a named file system with up to 64 distinct files on each flexible disk. Each file can contain up to 240K bytes. Sequential and random access are provided. A table summary of its commands is shown below.

### Built-in Commands

**TYPE** Displays the contents of a file at the CRT Console.

**DIR** Directory: Displays file name and file type of all files present on a disk.

**REN** Rename: Changes a file name.

**ERA** Erases a given file or set of files from the disk.

**SAVE** Saves a portion of System Memory (RAM) on the disk as a named file.

### Transient Commands

**ED** The **Editor** allows preparation of programs and text using powerful context editing and display commands.

**PIP** Peripheral Interchange Program allows transfer of files between various peripherals and disk files.

Examples:

- Copy file from disk drive A to B.
- Output any disk file to the CRT Console or Printer.
- Read a paper tape onto disk.
- Copy and rename a given file.
- Concatenate files.

**SUBMIT** Allows commands to be batched together and be executed automatically.

**SET** Sets up system parameters.

**DUMP** Prints the contents of a file in "hex" and ASCII format at the CRT Console.

**SYSGEN** Initializes a flexible disk with the operating system.

**DISPL** Displays source and list files from the disk on the CRT Console.

**STAT** Statistics: Lists files by name, file space used by each, remaining disk space, device assignments. Allows user to change device assignments.

### Microprogram Generation Software

**AMDASM<sup>®</sup> 29** A microprogram assembler which can be personalized by defining a particular microcode format. It will then assemble the microcode from source to object code.

**AMSCRM<sup>®</sup> 29** Reorganizes the microprogram for a given PROM organization.

**AMPROM<sup>®</sup> 29** Outputs the microprogram in a form suitable to a given PROM organization.

**AMMAP<sup>®</sup> 29** Generates microprogram entry point addresses that are loaded into the CCU mapping RAM.

### Microprogram Support Software

These programs load, save, and debug microcode during the firmware/hardware check-out phase of the design.

**LBPM** Loads Bipolar Memory (BPM) from disk to Writable Control Store (WCS) or Mapping RAM (MAP).

**VBPM** Verifies BPM—compares data in WCS or MAP with data on disk.

**SBPM** Saves BPM—saves on disk, the microprogram stored in WCS or MAP.

**RBPM** Restores BPM—reloads the saved microprogram.

**DDT29** Dynamic Debugging Tool allows dynamic manipulation while running the microprogram. Commands such as TRACE, STEP, HALT, RUN, DISPLAY, MODIFY, and JUMP offer complete control over the microprogrammed processor.

### Am9080A Software

This software allows the writing of programs for Am9080A fixed-instruction-set microprocessor design for the customization of System 29 by writing special programs for its Am9080A-based Support Processor.

**ASM** Am9080A Assembler

**DDT** Dynamic Debugging Tool is a monitor that allows symbolic program tracing, debugging, and testing. DDT contains a complete Am9080A Disassembler.

**LOAD** The loader prepares a memory image file from an assembled file, ready for direct execution.

## MICROPROGRAMMING SOFTWARE GENERATION

## TYPICAL DEFINITION FILE

```

;
;AM2909 NEXT MICROINSTRUCTION ADDRESS SELECT DEFINITIONS
;
CJR:    DEF      4VX,H#0,24X    ;JUMP REGISTER IF F 0
JR:     DEF      4VX,H#1,24X    ;JUMP REGISTER
CONT:   DEF      4VX,H#2,24X    ;CONTINUE
JMAP:   DEF      4VX,H#3,24X    ;JUMP MAP
CJSR:   DEF      4VX,H#4,24X    ;JUMP SUBROUTINE IF F 0
JSR:    DEF      4VX,H#5,24X    ;JUMP TO SUBROUTINE (CALL)
RTN:    DEF      4VX,H#6,24X    ;RETURN FROM SUBROUTINE
LOOP:   DEF      4VX,H#7,24X    ;FILE REFERENCE
ELPF0:  DEF      4VX,H#8,24X    ;END LOOP & POP IF F=0
PUSH:   DEF      4VX,H#9,24X    ;PUSH PC AND CONTINUE
POP:    DEF      4VX,H#A,24X    ;POP AND CONTINUE
ELPCN4: DEF      4VX,H#B,24X    ;END LOOP & POP IF CN+4
JRF0:   DEF      4VX,H#C,24X    ;JUMP REGISTER IF F=0
JRF3:   DEF      4VX,H#D,24X    ;JUMP REGISTER IF F3
JROVR:  DEF      4VX,H#E,24X    ;JUMP REGISTER IF OVR
JRCN4:  DEF      4VX,H#F,24X    ;JUMP REGISTER IF CN4
;
;OTHER DEFINITIONS
;
AM2901: DEF      9X,3VQ#1,1X,3VX,1VX,3VX,4VX,4VX,4X
DATA:   DEF      28X,4VH# ;DEF TO SUPPLY ALU DATA INPUT

```

## TYPICAL MICROPROGRAM SOURCE FILE

AMD AMDASM MICRO ASSEMBLER, V1.0  
AM2900 KIT EXERCISE #10

PAGE 1

```

;AMDASM EXAMPLE, ASSEMBLY PHASE
;
0000      CONT      & AM2901 RAMF,DZ,,OR,,R0 & DATA H#F ; 1
0001      CONT      & AM2901 RAMF,DZ,,OR,,R1 & DATA 9 ; 2
0002      CONT      & AM2901 RAMF,DZ,,OR,,R2 & DATA B#0001 ; 3
0003      CONT      & AM2901 RAMF,DZ,,OR,,R4 & DATA 4 ; 4
0004      PUSH      & AM2901 RAMF,ZB,,AND,,R3 ; 5
0005 BEGIN:: CONT    & AM2901 ,DA,,AND,R0,R0 & DATA 1 ; 6
0006      CJSR      INCR3 & AM2901 RAMD,ZB,,OR,,R0 ; 7
0007      CONT      & AM2901 ,DA,,AND,R1,R1 & DATA 1 ; 8
0008      CJSR      INCR3 & AM2901 RAMD,ZB,,OR,,R1 ; 9
0009      CONT      & AM2901 ,DA,,AND,R2,R2 & DATA 1 ; 10
000A      CJSR      INCR3 & AM2901 RAMD,ZB,,OR,,R2 ; 11
000B      CONT      & AM2901 RAMF,ZB,CN0,SUBR,,R4 ; 12
000C      ELPF0     & AM2901 ; 13
000D STOP:: JR      STOP & AM2901 ,ZB,,OR,,R3 ; 14
000F      ORG      15 ; 15
000F INCR3:: RTN     & AM2901 RAMF,ZB,CN1,ADD,,R3 ; 16
;
END

```

```

0000 XXXX0010X011X111 X011XXXX00001111
0001 XXXX0010X011X111 X011XXXX00011001
0002 XXXX0010X011X111 X011XXXX00100001
0003 XXXX0010X011X111 X011XXXX01000100
0004 XXXX1001X011X011 X100XXXX0011XXXX
0005 XXXX0010X001X101 X1000000000000001
0006 11110100X101X011 X011XXXX0000XXXX
0007 XXXX0010X001X101 X100000100010001
0008 11110100X101X011 X011XXXX0001XXXX
0009 XXXX0010X001X101 X100001000100001
000A 11110100X101X011 X011XXXX0010XXXX
000B XXXX0010X011X011 0001XXXX0100XXXX
000C XXXX1000X001XXXX XXXXXXXXXXXXXXXX
000D 11010001X001X011 X011XXXX0011XXXX
000F XXXX0110X011X011 1000XXXX0011XXXX

```

## **MICROPROGRAM CHECK-OUT SOFTWARE**

### **MANIPULATE MICROCODE IN WCS OR MAPPING RAM**

- LBPM: LOAD FROM DISK
- VBPM: VERIFY AFTER LOAD
- SBPM: SAVE ON DISK
- RBPM: RESTORE AFTER SAVE

## **MICROPROGRAM CHECK-OUT SOFTWARE DDT29 — A MICROCODE DEBUGGER**

- **MANIPULATE MICROCODE IN WCS OR MAPPING RAM**
  - DISPLAY, MODIFY
- **CLOCK CONTROL**
  - HALT, SINGLE STEP, MICROSTEP, RUN
  - BREAKPOINT TRAP
- **BRANCH CONTROL**
  - ADDRESS JAMMING
- **SINGLE LEVEL TRACE**
  - DISPLAY 20 MONITOR BITS
- **BATCH CAPABILITY**

## Using the System 29

System 29 is useful to the microprogrammed system designer from initial hardware/firmware design to final interface and debugging. It also provides a production test station after the design has been completed.

□ **System Initialization** is as simple as pressing a front panel button. AMDOS 29 is automatically loaded from disk to RAM System Memory and System 29 is ready to work.

□ **Logic Design.** Mount logic circuits on the Universal Prototyping Card which plugs directly inside the System Mainframe. Alternatively, connect an outboard design via cable interface.

At any time you can write simple programs that will analyze the logic design, wiring errors, and component failures.

□ **Microcode Generation.** Once the microcode format has been set, the AMDASM 29 assembler can be personalized. This is the Definition Phase. System 29 acts as an interactive CRT Console as the Editor is used to build the Definition File. The next step is to generate the microcode source files, written in mnemonic language, again using the interactive Editor. The assembly process then turns these source files into object files, i.e., a binary representation of the microcode (1's, 0's and "don't cares"). When the assembly is completed, they are routed to disk storage.

□ **Microcode Check-out.** Once the microcode (firmware) has been assembled and the logic design has been checked-out, they are ready to be interfaced, using System 29 as a check-out station. Load the microcode into Writable Control Store (microprogram memory) and begin using the System 29 features available to:

Verify and edit microcode in WCS.

Run, halt, and single-step the microprogram.

Stop or breakpoint an address, or a sequence of addresses, input from the keyboard.

Branch or force a particular address onto the microprogram for one microcycle.

Generate and debug sequences of microcode written explicitly for hardware debugging purposes and not a permanent part of the final microcode.

Monitor some 64 test points in real-time.

□ **Firmware Post-Processing.** When microcode check-out has been completed, AMPROM 29 will output the microcode on the optional Paper Tape Punch in a format appropriate for a given PROM programmer. Alternatively, the output can be sent to an optional PROM programmer connected directly to System 29. AMSCRM 29 allows reorganization of the microinstruction fields for various PROM organizations before outputting the microcode.

## Complete support

System 29 comes with complete support:

Training courses for two engineers on microprogramming techniques and the detailed use of the system; a complete documentation package; an extensive warranty and service plan for both hardware and software products after installation at your facilities; the active participation of a team of Field Application Engineers fully trained on the use of the system and the design of microprogrammed systems.



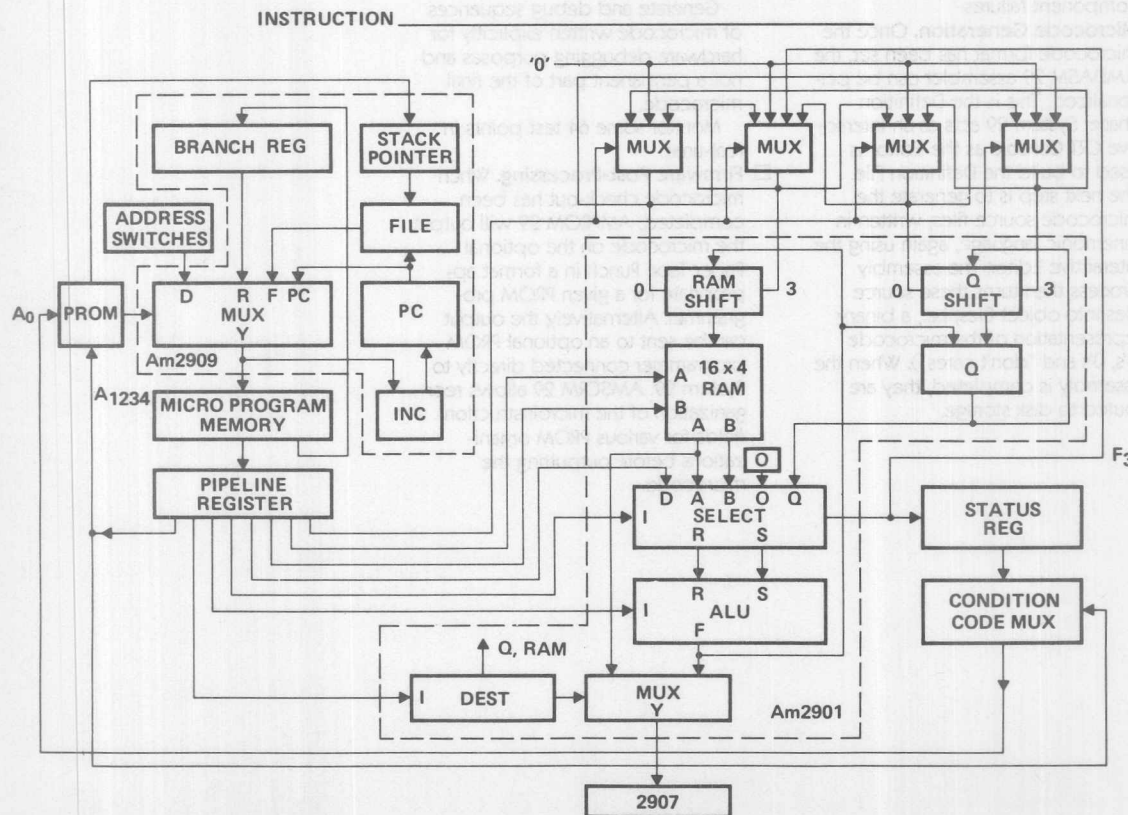
## EXAMPLE OF System 29 DEVELOPMENT

The capabilities of SYSTEM 29 can be demonstrated by microprogramming one of the exercises from the Am2900 Learning and Evaluation Kit. This kit provides a simple but complete example of a microprogrammed system.

The architecture of the kit is shown in Figure 5-1. The dashed lines outline the two LSI components, the Am2909 microprogram sequencer and the Am2901 four-bit slice microprocessor. Each microinstruction in the microprogram memory consists of 32 bits

divided into fields to control the sequencer, branch address, shift multiplexers, and all the inputs to the Am2901. The fields and their functions are defined in Figure 5-2.

The first step in using SYSTEM 29 is the creation of a set of definitions which reflect the hardware on which the microprogram will run. The statements in Figure 5-3 completely define, mnemonically, the fields in the kit. That is, they implement exactly the fields and their functions for the microprocessor architecture defined in Figure 5-1, and so may be used in writing all microprograms that are to operate in this architecture. Figure 5-4 shows a flow chart of the program to be written. Figure 5-5 is the SYSTEM 29 output in Block format.



AMC-009

Figure 5-1. Am2900 Learning and Evaluation Kit Architecture.



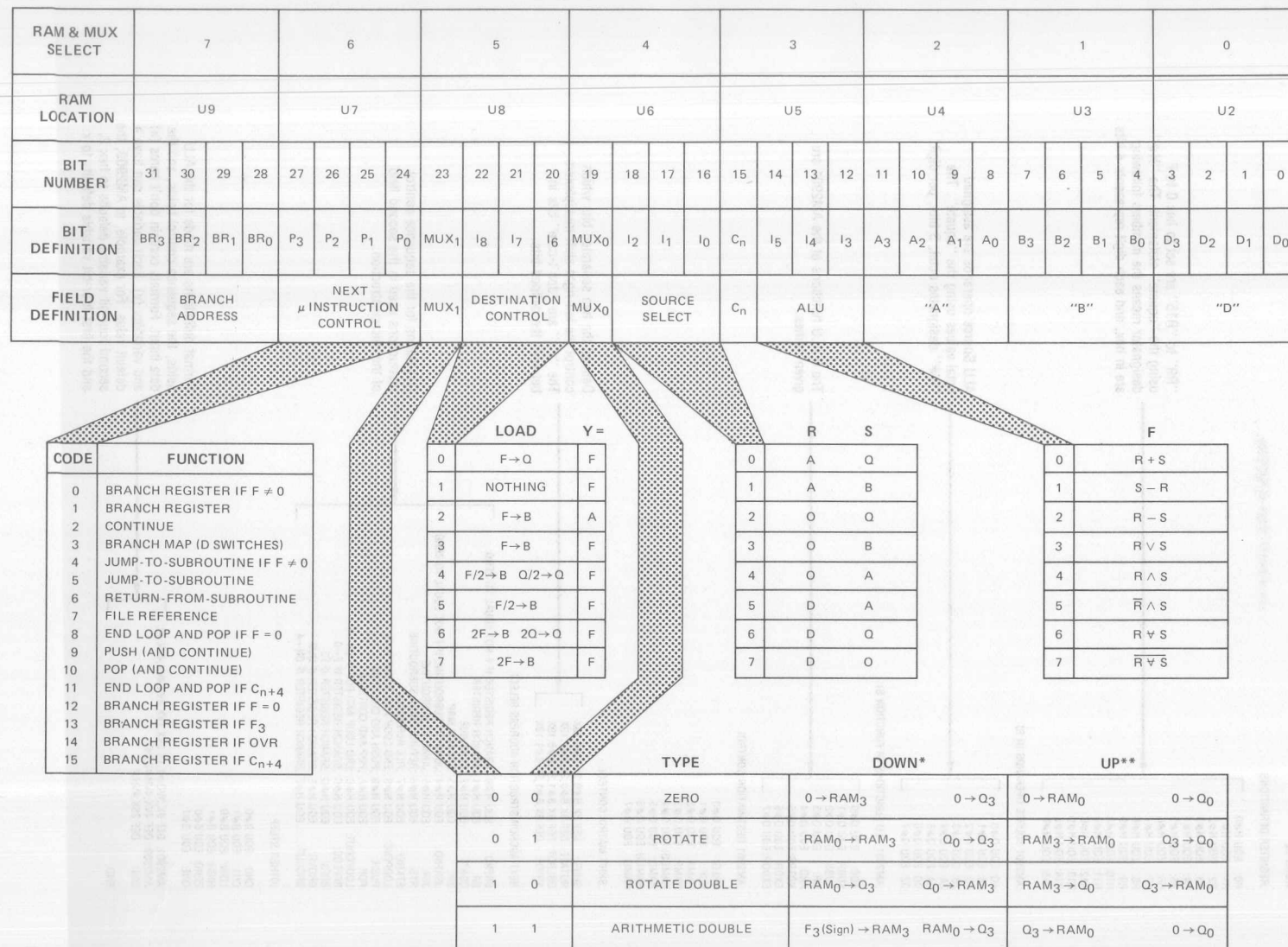


Figure 5-2. Example of Fields and Functions.

## REGISTER DEFINITIONS

```

R0: EQU H#0
R1: EQU H#1
R2: EQU H#2
R3: EQU H#3
R4: EQU H#4
R5: EQU H#5
R6: EQU H#6
R7: EQU H#7
R8: EQU H#8
R9: EQU H#9
R10: EQU H#A
R11: EQU H#B
R12: EQU H#C
R13: EQU H#D
R14: EQU H#E
R15: EQU H#F

```

"R0" to "R15" are set to hex 0 to F using the "equate" statement. The "H#" designator means the numbers following are in hex, and each digit represents 4 bits.

## AM2901 SOURCE OPERANDS (R S)

```

AQ: EQU Q#0
AB: EQU Q#1
ZQ: EQU Q#2
ZB: EQU Q#3
ZA: EQU Q#4
DA: EQU Q#5
DQ: EQU Q#6
DZ: EQU Q#7

```

ALU Source operands are assigned octal values using the "equate". The "Q#" designates octal, 3 bits, per digit.

## AM2901 ALU FUNCTIONS (R FUNCTION S)

```

ADD: EQU Q#0
SUBR: EQU Q#1
SUBS: EQU Q#2
OR: EQU Q#3
AND: EQU Q#4
NOTRS: EQU Q#5
EXOR: EQU Q#6
EXNOR: EQU Q#7

```

The 8 ALU functions of the AM2901 are given names.

## AM2901 DESTINATION CONTROL

```

QREG: EQU Q#0
NOP: EQU Q#1
RAMA: EQU Q#2
RAMF: EQU Q#3
RAMOD: EQU Q#4
RAMD: EQU Q#5
RAMQU: EQU Q#6
RAMU: EQU Q#7

```

## SHIFT MATRIX CONTROL

```

SHIFT: DEF 8X,B#0,3X,B#0,19X
ROTATE: DEF 8X,B#0,3X,B#1,19X
DBLROT: DEF 8X,B#1,3X,B#0,19X
ARITH: DEF 8X,B#1,3X,B#1,19X

```

Defines the two separated bits which control the left-right shift multiplexers. The "x's" are "don't-care" bits in between the defined bits.

## NEXT MICROINSTRUCTION ADDRESS SELECT

```

BRFNO: EQU H#0 ;BRANCH REGISTER IF F NOT EQUAL TO ZERO
BR: EQU H#1 ;BRANCH REGISTER
CONT: EQU H#2 ;CONTINUE
BM: EQU H#3 ;BRANCH MAP
JSRFRNO: EQU H#4 ;JUMP-TO-SUBROUTINE IF F NOT EQUAL TO ZERO
JSR: EQU H#5 ;JUMP-TO-SUBROUTINE
RTS: EQU H#6 ;RETURN FROM SUBROUTINE
STKREF: EQU H#7 ;FILE REFERENCE
LOOPFNO: EQU H#8 ;END LOOP AND POP IF F=0
PUSH: EQU H#9 ;PUSH AND CONTINUE
POP: EQU H#A ;POP AND CONTINUE
LOOPCOUT: EQU H#B ;END LOOP AND POP IF CN+4
BRFEO: EQU H#C ;BRANCH REGISTER IF F=0
BRF3: EQU H#D ;BRANCH REGISTER IF F3
BROVR: EQU H#E ;BRANCH REGISTER IF OVR
BRCOUT: EQU H#F ;BRANCH REGISTER IF CN+4

```

Definitions for the sequence control instructions used in the second field of the microinstruction.

## OTHER STUFF

```

CNO: EQU B#0
CN1: EQU B#1
LOW: EQU B#0
HIGH: EQU B#1
ZERO: EQU B#0
ONE: EQU B#1

```

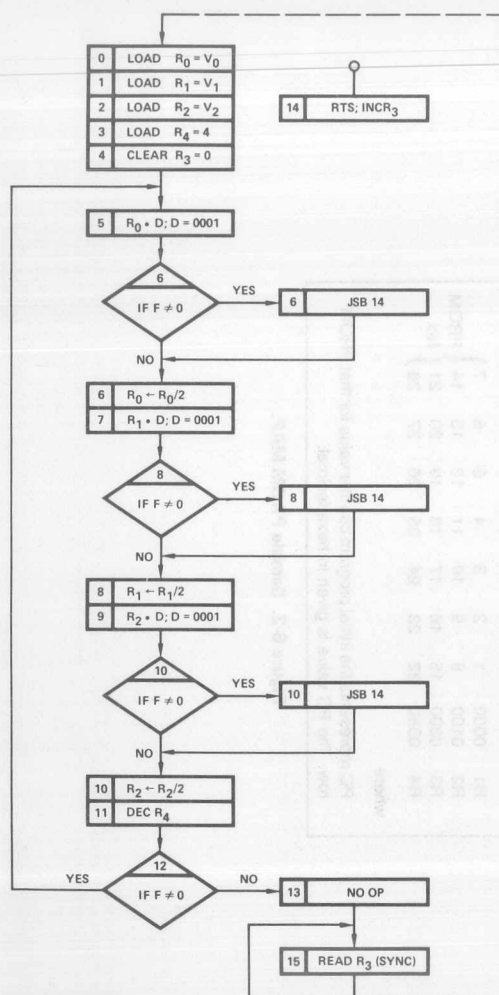
```

AM2901: DEF 9X,3VQ#1,1X,3VX,1VX,3VX,4VX,4VX,4X
AM2909: DEF 4VX,4VH#2,24X
DIN: DEF 28X,4VH#
END

```

Format definitions are made for the ALU fields, the sequence control fields, and the data input. Formats contain don't cares (x) and variables (v). Each variable can have a default value. For example, in AM2909, the second four-bit variable defaults to hex 2, and the first four-bit variable defaults to x.

Figure 5-3. Definition File.



AMDASM29-2

Figure 5-4. Flow Chart of Example.

```

0000 AM2909 & AM2901 RAMF, DZ,,OR,,R0 & DIN H#F
0001 AM2909 & AM2901 RAMF, DZ,,OR,,R1 & DIN 9
0002 AM2909 & AM2901 RAMF, DZ,,OR,,R2 & DIN 0
0003 AM2909 & AM2901 RAMF, DZ,,OR,,R4 & DIN 4
0004 AM2909 & AM2901 RAMF, ZB,,AND,,R3
0005 A5: AM2909 & AM2901 ,DA,,AND,R0,R0 & DIN 1
0006 AM2909 A14,JSRFN0 & AM2901 RAMD, ZB,,OR,,R0
0007 AM2909 & AM2901 ,DA,,AND,R1,R1 & DIN 1
0008 AM2909 A14,JSRFN0 & AM2901 RAMD, ZB,,OR,,R1
0009 AM2909 & AM2901 ,DA,,AND,R2,R2 & DIN 1
000A AM2909 A14,JSRFN0 & AM2901 RAMD, ZB,,OR,,R2
000B AM2909 & AM2901 RAMF, ZB, CN0,SUBR,,R4
000C AM2909 A5,BRFN0 & AM2901
000D AM2909 A15,BR & AM2901
000E A14: AM2909 ,RTS & AM2901 RAMF, ZB,CN1,ADD,,R3
000F A15: AM2909 A15,BR & AM2901 ,ZB,,OR,,R3
END

```

```

0000 XXXX0010X011X111 X011XXXX00001111
0001 XXXX0010X011X111 X011XXXX00011001
0002 XXXX0010X011X111 X011XXXX00100000
0003 XXXX0010X011X111 X011XXXX01000100
0004 XXXX0010X011X011 X100XXXX0011XXXX
0005 XXXX0010X001X101 X100000000000001
0006 11100100X101X011 X011XXXX0000XXXX
0007 XXXX0010X001X101 X100000100010001
0008 11100100X101X011 X011XXXX0001XXXX
0009 XXXX0010X001X101 X1000001000100001
000A 11100100X101X011 X011XXXX0010XXXX
000B XXXX0010X011X011 0001XXXX0100XXXX
000C 01010000X001XXXX XXXXXXXXXXXXXXXX
000D 11110001X001XXXX XXXXXXXXXXXXXXXX
000E XXXX0110X011X011 1000XXXX0011XXXX
000F 11110001X001X011 X011XXXX0011XXXX

```

Figure 5-5. Assembly Output in Block Diagram.

## RESULTANT PROM SET

When a user has completed an assembly, he may wish to output his binary object code in a form which corresponds with his PROMs' organization and/or he may wish to punch the object code from his program onto paper tapes to be used as input to a PROM burner.

## PROM ORGANIZATION

The assembler generates binary object code for the executable statements in the file named ASM.

This binary object code is output to a file called PRMOUT.

For our example we shall assume that the microword is 48 bits wide and the number of executable statements is 1024.

This gives us a matrix 48 wide by 1024 deep as shown in Figure 6-1.

| Bit No.     | 1    | 2 | 3 | 4 | ..... | 48 |
|-------------|------|---|---|---|-------|----|
| Executable  | 1    |   |   |   |       |    |
| Instruction | 2    |   |   |   |       |    |
| Number      | 3    |   |   |   |       |    |
|             | 4    |   |   |   |       |    |
|             | .    |   |   |   |       |    |
|             | .    |   |   |   |       |    |
|             | .    |   |   |   |       |    |
|             | 1024 |   |   |   |       |    |

Figure 6-1. Bit Matrix

After PROM width and depth are specified, the Bit Matrix is subdivided to yield a PROM Map where each PROM is  $n$  bits wide by  $m$  bits deep. If we assume that the program origin is zero for our example, the actual PROM MAP printed might appear as shown in Figure 6-2.

|    | PC   | C1 | C2 | C3 | C4 | C5 | C6 | C7 |               |
|----|------|----|----|----|----|----|----|----|---------------|
| R1 | 0000 | 1  | 2  | 3  | 4  | 5  | 6  | 7  | } PROM<br>No. |
| R2 | 0100 | 8  | 9  | 10 | 11 | 12 | 13 | 14 |               |
| R3 | 0300 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |               |
| R4 | 0380 | 22 | 23 | 24 | 25 | 26 | 27 | 28 |               |

where

PC represents the initial program counter value for that PROM row. The PC value is given in hexadecimal.

Figure 6-2. Sample PROM MAP.

For the example, PROMs shall be organized as shown in Figure 6-3.

Each executable instruction naturally has a program counter associated with it by virtue of its position in the program and/or the origin(s) that were set during the assembly execution.

This breakup of the matrix is now called a PROM map which has associated with it, not only the PROMs shown, but rows and columns as shown in Figure 6-3. Thus, we may now refer to PROM 19 by using the digits 19, or by referencing R3 for Row 3 and C5 for Column 5.

As shown in Figure 6-4, all PROMs in Row 1 are 256 (instructions) deep, but PROMs 1, 3, 5, and 6 are only 4 bits wide, while PROMs 2 and 7 are 8 bits wide and PROM 4 is 16 bits wide.

In Row 2, all PROMs are 512 (instructions) deep and PROMs 8, 10, 12 and 13 are 4 bits wide, PROMs 9 and 14 are 8 bits wide and PROM 11 is 16 bits wide.

Rows 3 and 4 are each 128 (instructions) deep; PROMs 15, 22, 17, 24, 19, 26, 20, and 27 are 4 bits wide; PROMs 16, 23, 21, and 28 are 8 bits wide; and PROMs 18 and 25 are 16 bits wide.

If the user requests printing (or punching) of PROM #1 he will obtain data that is 4 by 256.

If the user requests printing of Row 3, he will obtain data (i.e., the contents of PROMs 15 through 21) in the following form:

4 X 128, 8 X 128, 4 X 128, 16 X 128, 4 X 128, 4 X 128, 8 X 128

If the user requests printing of Column 4 he will obtain data (i.e., the contents of PROMs 4, 11, 18, and 25) that is:

16 X 256, 16 X 512, 16 X 128, 16 X 128

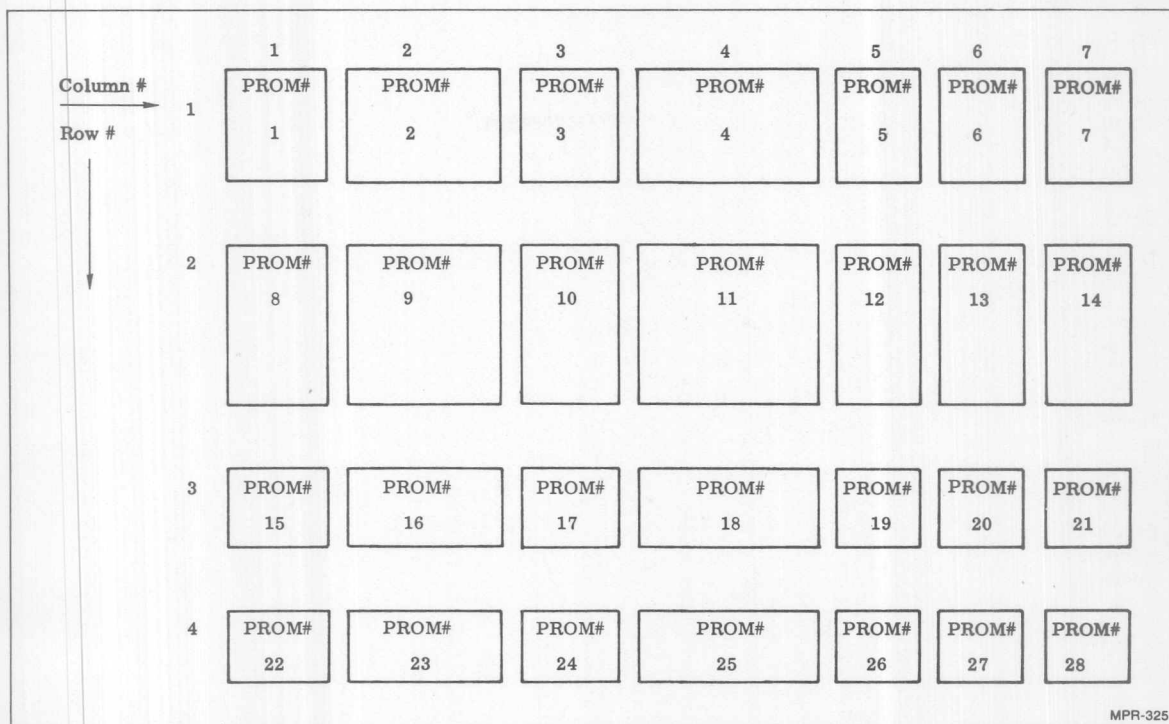


Figure 6-3. PROM MAP

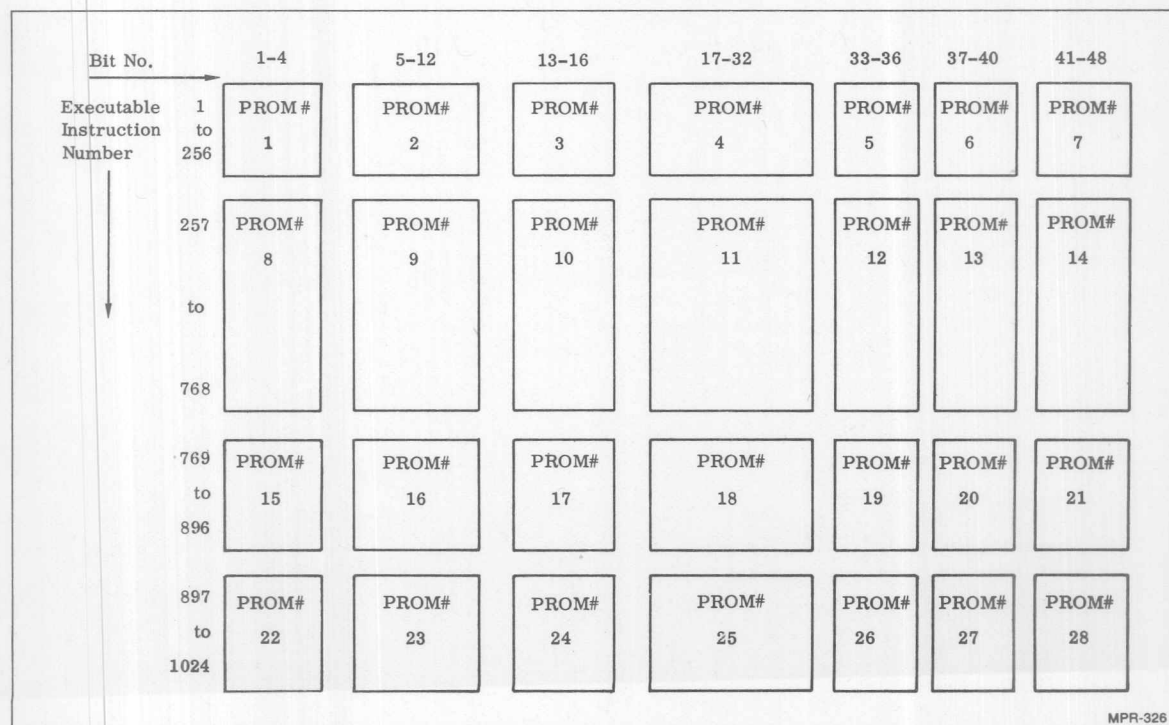


Figure 6-4. Organization of PROMs



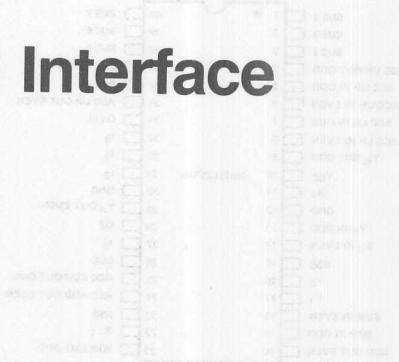


# MULTIPLIERS

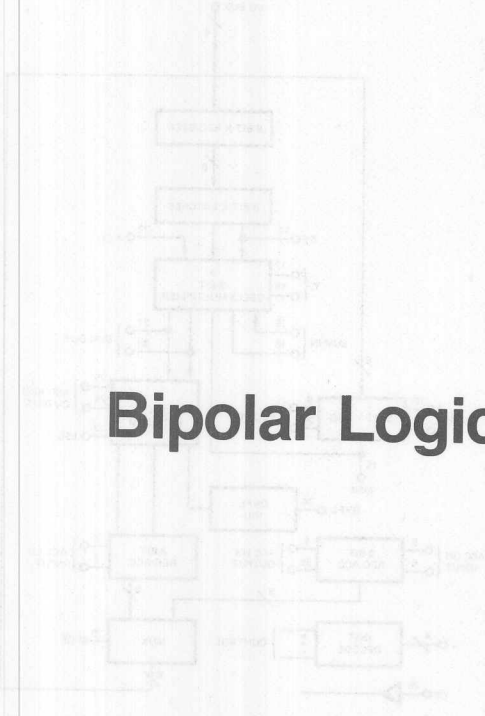
## Am252527

- 8-bit by 8-bit multiplier
- Two's complement, two-bit signed carry arithmetic
- Microprogrammable - four-bit instruction code for load, multiply, and read operations
- Cascadeable - two devices perform full 16-bit multiplication without additional hardware
- 8-bit bus parallel, bidirectional, bus-to-bus
- On-chip registers and code memory
- Overflow indicator
- Three-state shared bus
- High-speed architecture provides clock rates of 20MHz typ.

### CONNECTION DIAGRAM



### LOGIC DIAGRAM



# Bipolar Logic and Interface

4

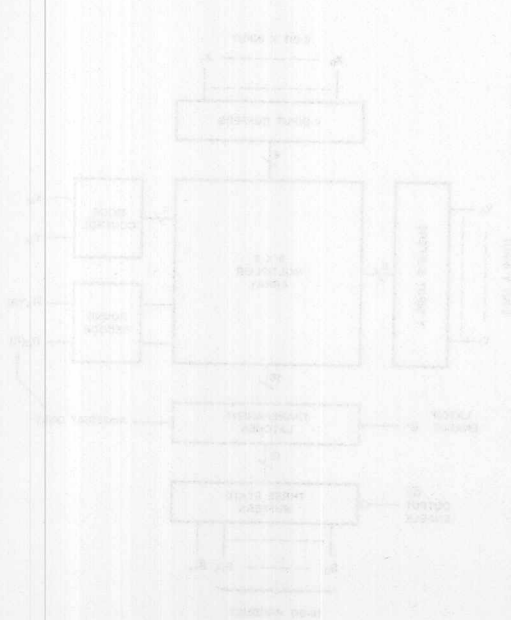
## Am252527 - Am252528

- 8-bit by 8-bit combinational multiplier
- Full 8 x 8 multiply in 4ns typ
- Cascadeable to 16 x 16 in 110ns typ
- Unsigned, two's complement or mixed operands
- MSB and LSB outputs for easy expansion
- Incremental common rounding algorithm with additional logic
- Three-state outputs
- Transparent 16-bit bus in Am252527

### CONNECTION DIAGRAM



### LOGIC DIAGRAM



\*Pin 10 is for Am252527 and Pin 11 for Am252528

Pin assignments shown are for Am252527, B and R shown in parentheses and are common to Am252527

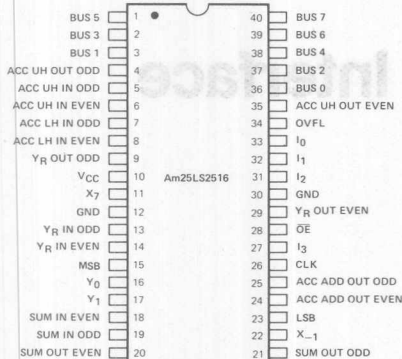
Refer to General and Low-Power Bipolar Data Book for complete pinout data

# MULTIPLIERS

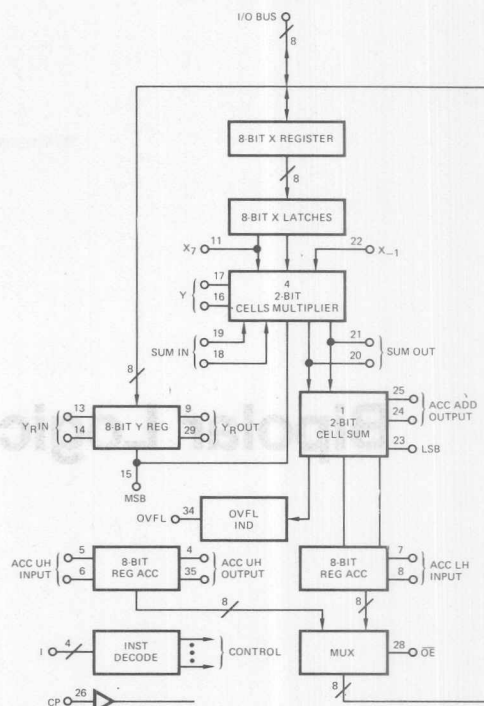
## Am25LS2516

- 8-bit by 8-bit serial/parallel multiplier
- Two's complement, two-bit look-ahead carry-save arithmetic
- Microprogrammable – four-bit instruction code for load, multiply, and read operations
- Cascadable, two devices perform full 16-bit multiplication without additional hardware
- 8-bit byte parallel, bidirectional, bussed I/O
- On-chip registers and double length accumulator
- Overflow indicator
- Three-state shared bus input/output lines
- High-speed architecture provides clock rates of 20MHz typ.

### CONNECTION DIAGRAM



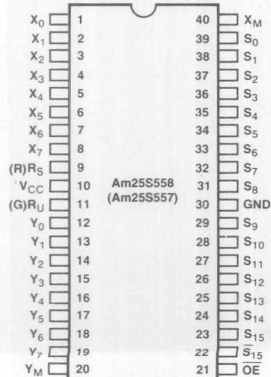
### LOGIC DIAGRAM



## Am25S557 • Am25S558

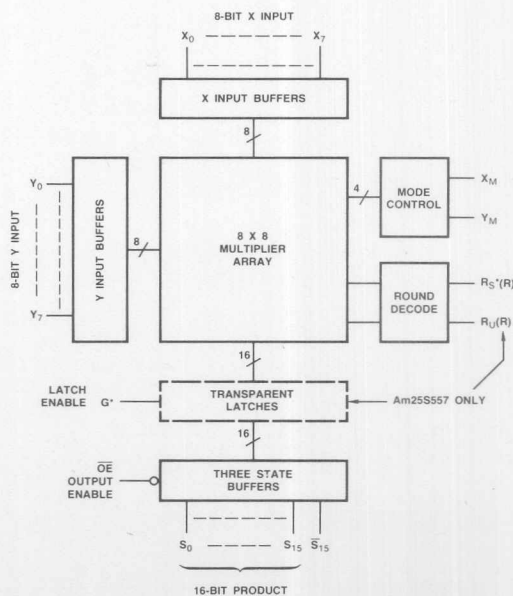
- 8-bit by 8-bit combinatorial multiplier
- Full 8 x 8 multiply in 45ns typ.
- Cascades to 16 x 16 in 110ns typ.
- Unsigned, two's complement or mixed operands
- MSB and MSB outputs for easy expansion
- Implements common rounding algorithms with additional logic
- Three-state outputs
- Transparent 16-bit latch in Am25S557

### CONNECTION DIAGRAM



Pin assignments shown are for Am25S558. G and R shown in parentheses are pin assignments for Am25S557.

### LOGIC DIAGRAM



\*Pin11 is G for Am25S557 and RU for Am25S558.

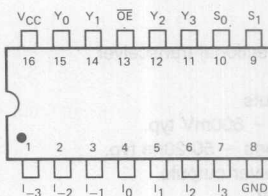
Refer to Schottky and Low-Power Schottky Data Book for complete product data.

# SHIFTERS

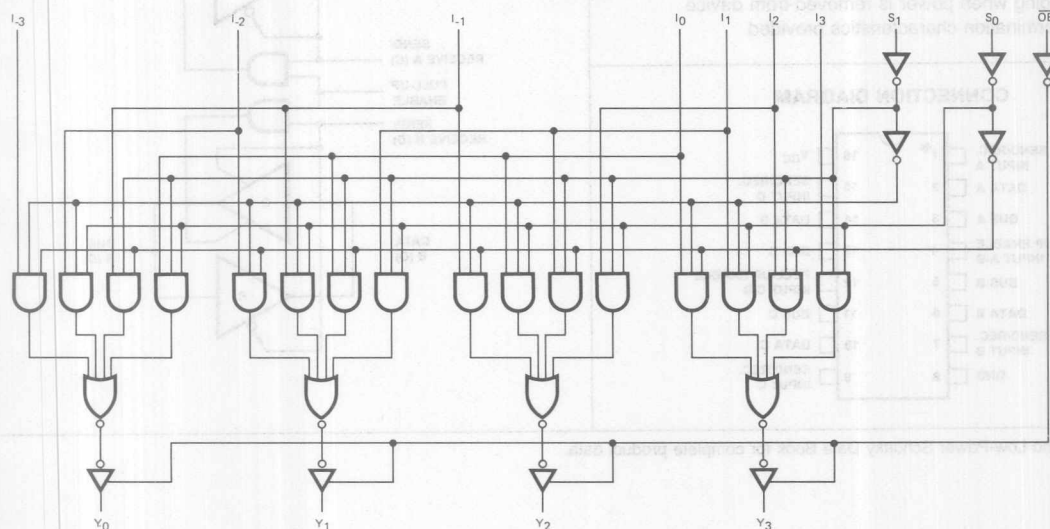
## Am25S10

- Shifts 4 bits 0, 1, 2 or 3 places
- Three-state outputs
- $t_{PD}$  6.5ns typ.
- Easy expansion to any number of bits without propagation delay increase

### CONNECTION DIAGRAM



### LOGIC DIAGRAM



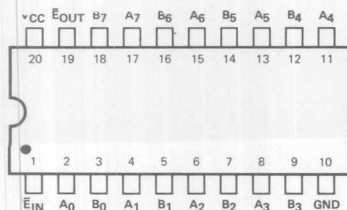
4

# COMPARATORS

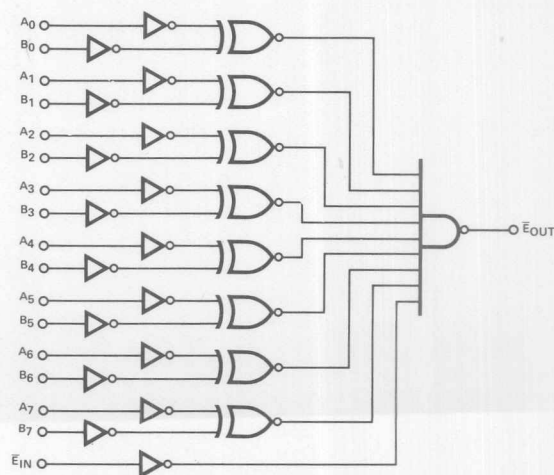
## Am25LS2521

- 8-bit byte oriented equal-to comparator
- Easily cascadable using  $\bar{E}_{IN}$
- Combinatorial logic with  $t_{PD} = 9.0ns$  typ.
- Broad application in conditional gating and microprocessor memory address decoding

### CONNECTION DIAGRAM



### LOGIC DIAGRAM

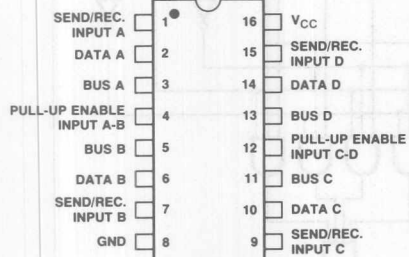


Refer to Schottky and Low-Power Schottky Data Book for complete product data.

## FEATURES

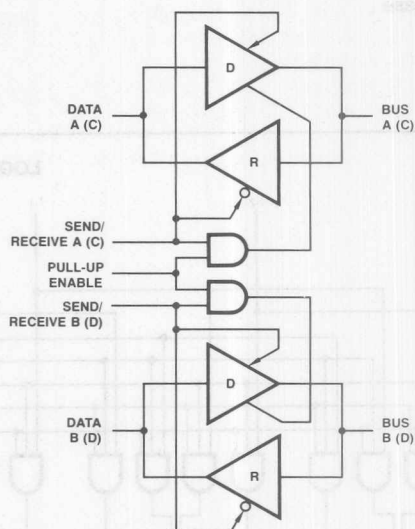
- IEEE-488 quad bidirectional transceiver
- Three-state outputs
- High impedance inputs
- Receiver hysteresis – 600mV typ.
- Fast propagation times – 50-20ns typ.
- TTL compatible receiver outputs
- Single +5 volt supply
- Open collector driver output option
- Power up/power down protection (No invalid information transmitted to bus)
- No bus loading when power is removed from device
- Required termination characteristics provided

## CONNECTION DIAGRAM



## LOGIC DIAGRAM

### 1/2 Am3448A



Refer to Schottky and Low-Power Schottky Data Book for complete product data.



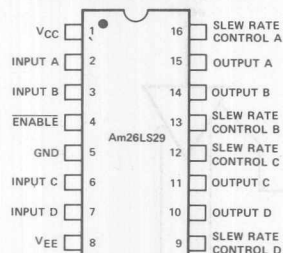
# LINE DRIVERS

## Am26LS29

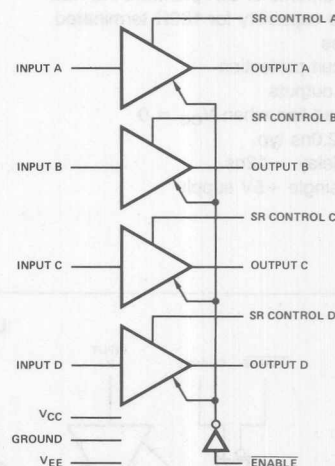
### FEATURES

- Four single-ended line drivers in one package
- Meets all requirements of RS-423
- Output short-circuit protection
- Individual rise time control for each output
- 50 $\Omega$  transmission line drive capability
- High capacitive load drive capability
- Low  $I_{CC}$  and  $I_{EE}$  power consumption (26mW/driver typ.)
- Three-state outputs for bus oriented systems
- Outputs do not clamp line with power off or in high-impedance state over entire transmission line voltage range of RS-423
- Low current PNP inputs compatible with TTL, MOS and CMOS

### CONNECTION DIAGRAM



### LOGIC DIAGRAM



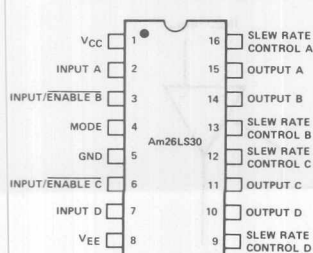
4

## Am26LS30

### FEATURES

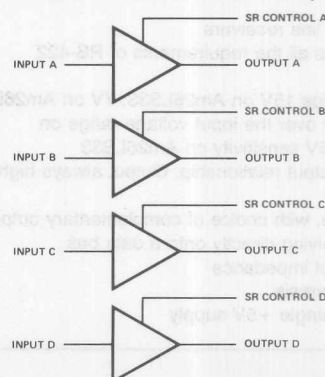
- Dual RS-422 line driver or quad RS-423 line driver
- Driver outputs do not clamp line with power off or in high-impedance state
- Individually three-state drivers when used in differential mode
- Low  $I_{CC}$  and  $I_{EE}$  power consumption
  - RS-422 differential mode 35mW/driver typ.
  - RS-423 single-ended mode 26mW/driver typ.
- Individual slew rate control for each output
- 50 $\Omega$  transmission line drive capability (RS-422 into virtual ground)
- Low current PNP inputs compatible with TTL, MOS and CMOS
- High capacitive load drive capability

### CONNECTION DIAGRAM

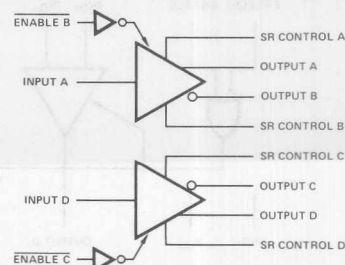


### LOGIC DIAGRAMS

#### Am26LS30 with Mode Control HIGH (RS-423)



#### Am26LS30 with Mode Control LOW (RS-422)



Refer to Schottky and Low-Power Schottky Data Book for complete product data.

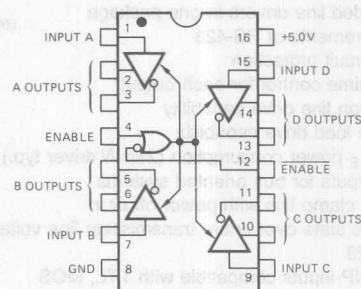
# LINE DRIVERS AND RECEIVERS

## Am26LS31

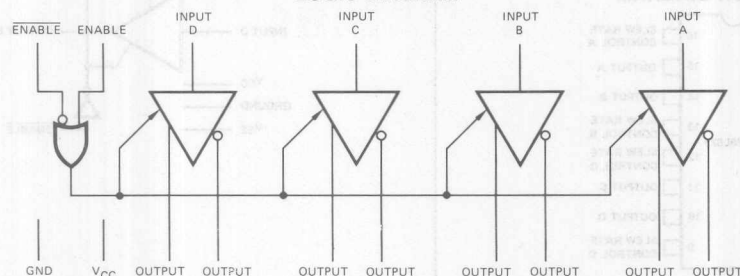
### FEATURES

- Four line drivers in one package
- Meets the requirements of EIA standard RS-422
- High output drive capability for 100Ω terminated transmission lines
- Output short-circuit protection
- Complementary outputs
- Outputs won't load line when  $V_{CC} = 0$
- Output skew – 2.0ns typ.
- Input to output delay – 12ns
- Operation from single +5V supply

### CONNECTION DIAGRAM



### LOGIC DIAGRAM

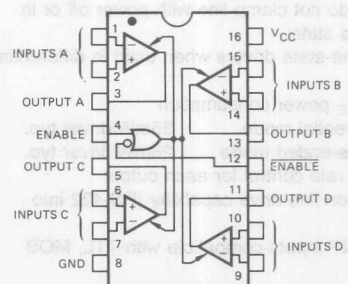


## Am26LS32 • Am26LS33

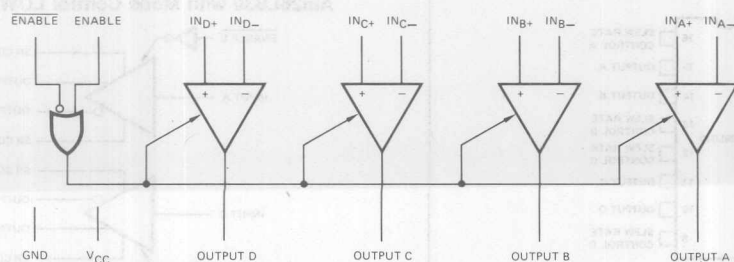
### FEATURES

- Quad differential line receivers
- Am26LS32 meets all the requirements of RS-422 and RS-423
- Input voltage range 15V on Am26LS33; 7V on Am26LS32
- $\pm 0.2V$  sensitivity over the input voltage range on Am26LS32;  $\pm 0.5V$  sensitivity on Am26LS33
- Fail safe input/output relationship. Output always high when inputs are open
- Three-state drive, with choice of complementary output enables, for receiving directly onto a data bus
- 6k minimum input impedance
- 30mV input hysteresis
- Operation from single +5V supply

### CONNECTION DIAGRAM



### LOGIC DIAGRAM



Refer to Schottky and Low-Power Schottky Data Book for complete product data.

# **Advanced Bipolar Memory**



# BIPOLAR MEMORY SELECTION GUIDE

## STATIC R/W RANDOM-ACCESS MEMORIES

| Part Number  | Organization | Maximum Access Time (ns) | Temp. Range | Operating Power – Max. (mW) | Outputs        |
|--------------|--------------|--------------------------|-------------|-----------------------------|----------------|
| Am3101       | 16 x 4       | 60                       | C           | 550                         | Open Collector |
| Am3101-1XC†  | 16 x 4       | 35                       | C           | 525                         | Open Collector |
| Am3101-1XM†  | 16 x 4       | 50                       | M           | 580                         | Open Collector |
| Am5489-1†    | 16 x 4       | 50                       | M           | 580                         | Open Collector |
| Am7489       | 16 x 4       | 60                       | C           | 550                         | Open Collector |
| Am7489-1†    | 16 x 4       | 35                       | C           | 525                         | Open Collector |
| Am31L01AXC   | 16 x 4       | 55                       | C           | 185                         | Open Collector |
| Am31L01AXM   | 16 x 4       | 65                       | M           | 210                         | Open Collector |
| Am27S02XC    | 16 x 4       | 35                       | C           | 550                         | Open Collector |
| Am27S02XM    | 16 x 4       | 50                       | M           | 580                         | Open Collector |
| Am27S03XC    | 16 x 4       | 35                       | C           | 550                         | 3-State        |
| Am27S03XM    | 16 x 4       | 50                       | M           | 580                         | 3-State        |
| Am27S02AXC   | 16 x 4       | 25                       | C           | 525                         | Open Collector |
| Am27S02AXM   | 16 x 4       | 30                       | M           | 580                         | Open Collector |
| Am27S03AXC   | 16 x 4       | 25                       | C           | 525                         | 3-State        |
| Am27S03AXM   | 16 x 4       | 30                       | M           | 580                         | 3-State        |
| Am27LS02XC   | 16 x 4       | 55                       | C           | 185                         | Open Collector |
| Am27LS02XM   | 16 x 4       | 65                       | M           | 210                         | Open Collector |
| Am27LS03XC   | 16 x 4       | 55                       | C           | 185                         | 3-State        |
| Am27LS03XM   | 16 x 4       | 65                       | M           | 210                         | 3-State        |
| Am27S06XC††  | 16 x 4       | 25                       | C           | 525                         | Open Collector |
| Am27S06XM††  | 16 x 4       | 30                       | M           | 580                         | Open Collector |
| Am27S07XC††  | 16 x 4       | 25                       | C           | 525                         | 3-State        |
| Am27S07XM††  | 16 x 4       | 30                       | M           | 580                         | 3-State        |
| Am27LS06XC†† | 16 x 4       | 55                       | C           | 185                         | Open Collector |
| Am27LS06XM†† | 16 x 4       | 65                       | M           | 210                         | Open Collector |
| Am27LS07XC†† | 16 x 4       | 55                       | C           | 185                         | 3-State        |
| Am27LS07XM†† | 16 x 4       | 65                       | M           | 210                         | 3-State        |
| Am27LS00AXC  | 256 x 1      | 35                       | C           | 525                         | 3-State        |
| Am27LS00AXM  | 256 x 1      | 45                       | M           | 550                         | 3-State        |
| Am27LS00XC   | 256 x 1      | 45                       | C           | 370                         | 3-State        |
| Am27LS00XM   | 256 x 1      | 55                       | M           | 385                         | 3-State        |
| Am27LS01AXC  | 256 x 1      | 35                       | C           | 525                         | Open Collector |
| Am27LS01AXM  | 256 x 1      | 45                       | M           | 550                         | Open Collector |
| Am27LS01XC   | 256 x 1      | 45                       | C           | 370                         | Open Collector |
| Am27LS01XM   | 256 x 1      | 55                       | M           | 385                         | Open Collector |
| Am93415XC    | 1024 x 1     | 45                       | C           | 815                         | Open Collector |
| Am93425XM    | 1024 x 1     | 60                       | M           | 935                         | 3-State        |
| *Am93412XC   | 256 x 4      | 45                       | C           | 815                         | Open Collector |
| *Am93422XM   | 256 x 4      | 60                       | M           | 935                         | 3-State        |

†Option of new improved Am27S02A featuring higher speed and write cycle transparency similar to Am3101 and Am7489

††Same as Am27S02A/03A and Am27LS02/03 respectively with non-inverting outputs

\*Available first quarter 1980

## READ-ONLY MEMORIES

| Part Number  | Organization | Access Time | Temp. Range | Power Supplies | Operating Power (mW) | Outputs        |
|--------------|--------------|-------------|-------------|----------------|----------------------|----------------|
| Am27S80XC    | 1024 x 8     | 175         | C           | +5V            | 895                  | Open Collector |
| Am27S80XM    | 1024 x 8     | 275         | M           | +5V            | 935                  | Open Collector |
| Am27S81XC    | 1024 x 8     | 175         | C           | +5V            | 895                  | 3-State        |
| Am27S81XM    | 1024 x 8     | 275         | M           | +5V            | 935                  | 3-State        |
| Am27S82XC††† | 1024 x 8     | 175         | C           | +5V            | 895                  | Open Collector |
| Am27S82XM††† | 1024 x 8     | 275         | M           | +5V            | 935                  | Open Collector |
| Am27S83XC††† | 1024 x 8     | 175         | C           | +5V            | 895                  | 3-State        |
| Am27S83XM††† | 1024 x 8     | 275         | M           | +5V            | 935                  | 3-State        |

†††Same as Am27S80 and Am27S81 with OR Enable Chip Select.



# BIPOLAR MEMORY SELECTION GUIDE

## PROGRAMMABLE READ-ONLY MEMORIES

| Part Numbers | Organization | Access Time | Temp. Range | Power Supplies | Operating Power (mW) | Package Pins | Outputs                    |
|--------------|--------------|-------------|-------------|----------------|----------------------|--------------|----------------------------|
| Am27S18XC    | 32 x 8       | 40          | C           | +5V            | 605                  | 16           | Open Collector             |
| Am27S18XM    | 32 x 8       | 50          | M           | +5V            | 635                  | 16           | Open Collector             |
| Am27S19XC    | 32 x 8       | 40          | C           | +5V            | 605                  | 16           | 3-State                    |
| Am27S19XM    | 32 x 8       | 50          | M           | +5V            | 635                  | 16           | 3-State                    |
| Am27LS20XC   | 256 x 4      | 45          | C           | +5V            | 685                  | 16           | Open Collector             |
| Am27LS20XM   | 256 x 4      | 60          | M           | +5V            | 715                  | 16           | Open Collector             |
| Am27LS21XC   | 256 x 4      | 45          | C           | +5V            | 685                  | 16           | 3-State                    |
| Am27LS21XM   | 256 x 4      | 60          | M           | +5V            | 715                  | 16           | 3-State                    |
| Am27S12XC    | 512 x 4      | 50          | C           | +5V            | 685                  | 16           | Open Collector             |
| Am27S12XM    | 512 x 4      | 60          | M           | +5V            | 715                  | 16           | Open Collector             |
| Am27S13XC    | 512 x 4      | 50          | C           | +5V            | 685                  | 16           | 3-State                    |
| Am27S13XM    | 512 x 4      | 60          | M           | +5V            | 715                  | 16           | 3-State                    |
| Am27S15XC    | 512 x 8      | 60          | C           | +5V            | 920                  | 24           | 3-State w/Latches          |
| Am27S15XM    | 512 x 8      | 90          | M           | +5V            | 1020                 | 24           | 3-State w/Latches          |
| Am27S25XC    | 512 x 8      | N.A.†       | C           | +5V            | 970                  | 24††         | 3-State w/Registers        |
| Am27S25XM    | 512 x 8      | N.A.†       | M           | +5V            | 1020                 | 24††         | 3-State w/Registers        |
| Am27S26XC    | 512 x 8      | N.A.†       | C           | +5V            | 970                  | 22           | Open Collector w/Registers |
| Am27S26XM    | 512 x 8      | N.A.†       | M           | +5V            | 1020                 | 22           | Open Collector w/Registers |
| Am27S27XC    | 512 x 8      | N.A.†       | C           | +5V            | 970                  | 22           | 3-State w/Registers        |
| Am27S27XM    | 512 x 8      | N.A.†       | M           | +5V            | 1020                 | 22           | 3-State w/Registers        |
| Am27S28XC    | 512 x 8      | 55          | C           | +5V            | 920                  | 20           | Open Collector             |
| Am27S28XM    | 512 x 8      | 70          | M           | +5V            | 965                  | 20           | Open Collector             |
| Am27S29XC    | 512 x 8      | 55          | C           | +5V            | 920                  | 20           | 3-State                    |
| Am27S29XM    | 512 x 8      | 70          | M           | +5V            | 965                  | 20           | 3-State                    |
| Am27S30XC    | 512 x 8      | 55          | C           | +5V            | 920                  | 24           | Open Collector             |
| Am27S30XM    | 512 x 8      | 70          | M           | +5V            | 965                  | 24           | Open Collector             |
| Am27S31XC    | 512 x 8      | 55          | C           | +5V            | 920                  | 24           | 3-State                    |
| Am27S31XM    | 512 x 8      | 70          | M           | +5V            | 965                  | 24           | 3-State                    |
| Am27S32XC    | 1024 x 4     | 55          | C           | +5V            | 735                  | 18           | Open Collector             |
| Am27S32XM    | 1024 x 4     | 70          | M           | +5V            | 800                  | 18           | Open Collector             |
| Am27S33XC    | 1024 x 4     | 55          | C           | +5V            | 735                  | 18           | 3-State                    |
| Am27S33XM    | 1024 x 4     | 70          | M           | +5V            | 800                  | 18           | 3-State                    |
| Am27S180XC   | 1024 x 8     | 60          | C           | +5V            | 920                  | 24           | Open Collector             |
| Am27S180XM   | 1024 x 8     | 80          | M           | +5V            | 1020                 | 24           | Open Collector             |
| Am27S181XC   | 1024 x 8     | 60          | C           | +5V            | 920                  | 24           | 3-State                    |
| Am27S181XM   | 1024 x 8     | 80          | M           | +5V            | 1020                 | 24           | 3-State                    |
| *Am27S184XC  | 2048 x 4     | 55          | C           | +5V            | 630                  | 18           | Open Collector             |
| *Am27S184XM  | 2048 x 4     | 70          | M           | +5V            | 715                  | 18           | Open Collector             |
| *Am27S185XC  | 2048 x 4     | 55          | C           | +5V            | 630                  | 18           | 3-State                    |
| *Am27S185XM  | 2048 x 4     | 70          | M           | +5V            | 715                  | 18           | 3-State                    |

†Normal Access time not applicable – this product contains built-in pipeline registers – nominal address to clock set-up time 40ns, clock to output 15ns.

††Slimline 300 mil pin centers.

\*Available second quarter 1980.

| Part Number | Organization | Access Time | Temp. Range | Power Supplies | Operating Power (mW) | Outputs                    |
|-------------|--------------|-------------|-------------|----------------|----------------------|----------------------------|
| Am27S18XC   | 32 x 8       | 40          | C           | +5V            | 605                  | Open Collector             |
| Am27S18XM   | 32 x 8       | 50          | M           | +5V            | 635                  | Open Collector             |
| Am27S19XC   | 32 x 8       | 40          | C           | +5V            | 605                  | 3-State                    |
| Am27S19XM   | 32 x 8       | 50          | M           | +5V            | 635                  | 3-State                    |
| Am27LS20XC  | 256 x 4      | 45          | C           | +5V            | 685                  | Open Collector             |
| Am27LS20XM  | 256 x 4      | 60          | M           | +5V            | 715                  | Open Collector             |
| Am27LS21XC  | 256 x 4      | 45          | C           | +5V            | 685                  | 3-State                    |
| Am27LS21XM  | 256 x 4      | 60          | M           | +5V            | 715                  | 3-State                    |
| Am27S12XC   | 512 x 4      | 50          | C           | +5V            | 685                  | Open Collector             |
| Am27S12XM   | 512 x 4      | 60          | M           | +5V            | 715                  | Open Collector             |
| Am27S13XC   | 512 x 4      | 50          | C           | +5V            | 685                  | 3-State                    |
| Am27S13XM   | 512 x 4      | 60          | M           | +5V            | 715                  | 3-State                    |
| Am27S15XC   | 512 x 8      | 60          | C           | +5V            | 920                  | 3-State w/Latches          |
| Am27S15XM   | 512 x 8      | 90          | M           | +5V            | 1020                 | 3-State w/Latches          |
| Am27S25XC   | 512 x 8      | N.A.†       | C           | +5V            | 970                  | 3-State w/Registers        |
| Am27S25XM   | 512 x 8      | N.A.†       | M           | +5V            | 1020                 | 3-State w/Registers        |
| Am27S26XC   | 512 x 8      | N.A.†       | C           | +5V            | 970                  | Open Collector w/Registers |
| Am27S26XM   | 512 x 8      | N.A.†       | M           | +5V            | 1020                 | Open Collector w/Registers |
| Am27S27XC   | 512 x 8      | N.A.†       | C           | +5V            | 970                  | 3-State w/Registers        |
| Am27S27XM   | 512 x 8      | N.A.†       | M           | +5V            | 1020                 | 3-State w/Registers        |
| Am27S28XC   | 512 x 8      | 55          | C           | +5V            | 920                  | Open Collector             |
| Am27S28XM   | 512 x 8      | 70          | M           | +5V            | 965                  | Open Collector             |
| Am27S29XC   | 512 x 8      | 55          | C           | +5V            | 920                  | 3-State                    |
| Am27S29XM   | 512 x 8      | 70          | M           | +5V            | 965                  | 3-State                    |
| Am27S30XC   | 512 x 8      | 55          | C           | +5V            | 920                  | Open Collector             |
| Am27S30XM   | 512 x 8      | 70          | M           | +5V            | 965                  | Open Collector             |
| Am27S31XC   | 512 x 8      | 55          | C           | +5V            | 920                  | 3-State                    |
| Am27S31XM   | 512 x 8      | 70          | M           | +5V            | 965                  | 3-State                    |
| Am27S32XC   | 1024 x 4     | 55          | C           | +5V            | 735                  | Open Collector             |
| Am27S32XM   | 1024 x 4     | 70          | M           | +5V            | 800                  | Open Collector             |
| Am27S33XC   | 1024 x 4     | 55          | C           | +5V            | 735                  | 3-State                    |
| Am27S33XM   | 1024 x 4     | 70          | M           | +5V            | 800                  | 3-State                    |
| Am27S180XC  | 1024 x 8     | 60          | C           | +5V            | 920                  | Open Collector             |
| Am27S180XM  | 1024 x 8     | 80          | M           | +5V            | 1020                 | Open Collector             |
| Am27S181XC  | 1024 x 8     | 60          | C           | +5V            | 920                  | 3-State                    |
| Am27S181XM  | 1024 x 8     | 80          | M           | +5V            | 1020                 | 3-State                    |
| *Am27S184XC | 2048 x 4     | 55          | C           | +5V            | 630                  | Open Collector             |
| *Am27S184XM | 2048 x 4     | 70          | M           | +5V            | 715                  | Open Collector             |
| *Am27S185XC | 2048 x 4     | 55          | C           | +5V            | 630                  | 3-State                    |
| *Am27S185XM | 2048 x 4     | 70          | M           | +5V            | 715                  | 3-State                    |

# Am27LS00/Am27LS01

Low-Power Schottky 256-Bit Random Access Memories

## Distinctive Characteristics

- Fully decoded 256-bit TTL RAMs.  
Plug-in replacements for 74200, 1M5503/5523, 93411/21  
Pin compatible with MM6530/31, 3106/7, 82S06, 74S201
- Open collector (Am27LS01) and three-state (Am27LS00)
- High speed operation:  
35ns typical access time  
45ns guaranteed (0°C to +75°C)  
55ns guaranteed (-55°C to +125°C)
- Very low power dissipation  
275mW typical  
70mA maximum I<sub>CC</sub>
- Full military temperature range performance.  
100% tested to GALPAT at -55°C and +125°C  
10% power supply tolerance
- Internal ECL circuitry  
Uniform access times over voltage and temperature variations.
- Tested to GALPAT.  
Functional and switching characteristics are guaranteed for all data and address patterns.

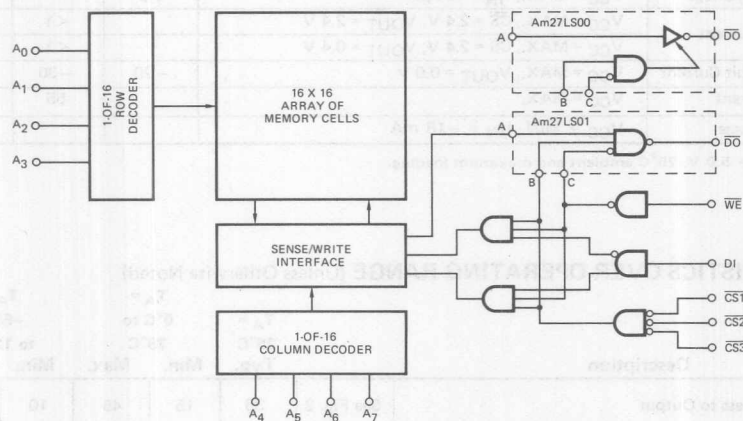
## FUNCTIONAL DESCRIPTION

The Am27LS00 and Am27LS01 are fully decoded bipolar random access memories for use in high-speed buffer memories and as a replacement for high-speed core memories in digital systems. The memories are organized 256-words by 1-bit with an 8-bit binary address field and separate data in and data output lines. The memories have three active LOW chip select inputs and a three-state output (Am27LS00) or open-collector output (Am27LS01). All inputs are buffered to present an input load of only 0.5 TTL unit loads.

Read/write operation is controlled by an active LOW write enable input. When the write enable is LOW and the chip is selected the data on the data input is written into the location specified by the address inputs. During this operation the output floats allowing the data bus to be used by other memories or open-collector logic elements that are tied to the inverting data output. Reading is accomplished by having the chip selected and the write enable input HIGH. Data stored in the location specified by the address inputs is read out and appears on the data output inverted.

The chip is selected by three active LOW inputs all of which must be LOW in order for the data output to be active during the read operation and for data to be written into or from the memory. These three active LOW chip select inputs permit the Am9301 or Am54LS/74LS138 MSI decoders to select memories in either a linear select, two or three dimensional mode of operation when large memory systems are being built. The delay from the chip select to the output is considerably faster than from the address inputs and extra delay can be tolerated in the chip select path without affecting system performance.

## LOGIC DIAGRAM



BPM-056

## ORDERING INFORMATION

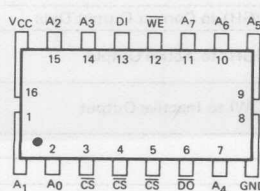
### Three-State Output

|              |                 |            |
|--------------|-----------------|------------|
| Molded DIP   | 0°C to +75°C    | AM27LS00PC |
| Hermetic DIP | 0°C to +75°C    | AM27LS00DC |
| Hermetic DIP | -55°C to +125°C | AM27LS00DM |
| Flat Pack    | -55°C to +125°C | AM27LS00FM |

### Open Collector Output

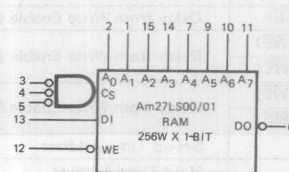
|              |                 |            |
|--------------|-----------------|------------|
| Molded DIP   | 0°C to +75°C    | AM27LS01PC |
| Hermetic DIP | 0°C to +75°C    | AM27LS01DC |
| Hermetic DIP | -55°C to +125°C | AM27LS01DM |
| Flat Pack    | -55°C to +125°C | AM27LS01FM |

## CONNECTION DIAGRAM Top View



Note: Pin 1 is marked for orientation.

## LOGIC SYMBOL



V<sub>CC</sub> = Pin 16  
GND = Pin 8

BPM-057

# Am27LS00/Am27LS01

## MAXIMUM RATINGS (Above which the useful life may be impaired)

|   |                                |
|---|--------------------------------|
| Storage Temperature   | −65°C to +150°C                |
| Temperature (Ambient) Under Bias                                | −55°C to +125°C                |
| Supply Voltage to Ground Potential (Pin 16 to Pin 8) Continuous | −0.5 V to +7 V                 |
| DC Voltage Applied to Outputs for High Output State             | −0.5 V to +V <sub>CC</sub> max |
| DC Input Voltage  | −0.5 V to +V <sub>CC</sub>     |
| Output Current, Into Outputs                                    | 30 mA                          |
| DC Input Current  | −30mA to +50mA                 |

## OPERATING RANGE

| Part No.                         | Ambient Operating Temperature | Power Supply Voltage |
|----------------------------------|-------------------------------|----------------------|
| Am27LS00DC, PC<br>Am27LS01DC, PC | 0°C to +75°C                  | 4.75 V to 5.25 V     |
| Am27LS00DM, FM<br>Am27LS01DM, FM | −55°C to +125°C               | 4.50 V to 5.50 V     |

## ELECTRICAL CHARACTERISTICS OVER OPERATING RANGE (Unless Otherwise Noted)

| Parameters      | Description                            | Test Conditions   | Min. | Typ.<br>(Note 1) | Max.  | Units |
|-----------------|--|---|------|------------------|-------|-------|
| V <sub>OH</sub> | Output HIGH Voltage<br>(Am27LS00 Only) | V <sub>CC</sub> = MIN., I <sub>OH</sub> = −2.0 mA (MIL Range)<br>V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub> , I <sub>OH</sub> = −2.6 mA (COM'L Range) | 2.4  | 3.1              |       | Volts |
| V <sub>OL</sub> | Output LOW Voltage                     | V <sub>CC</sub> = MIN., I <sub>OL</sub> = 16.0 mA, V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>   |      | 0.3              | 0.45  | Volts |
| V <sub>IH</sub> | Input HIGH Level                       | Guaranteed input logical HIGH voltage for all inputs  | 2.0  |                  |       | Volts |
| V <sub>IL</sub> | Input LOW Level                        | Guaranteed input logical LOW voltage for all inputs   |      |                  | 0.8   | Volts |
| I <sub>IL</sub> | Input LOW Current                      | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 0.4 V   |      | −0.50            | −0.80 | mA    |
| I <sub>IH</sub> | Input HIGH Current                     | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 2.7 V   |      | < 1              | 20    | μA    |
| V <sub>BK</sub> | Input Breakdown Voltage                | V <sub>CC</sub> = MAX., I <sub>IN</sub> = 100 μA  | 7.0  |                  |       | V     |
| I <sub>LK</sub> | Output Leakage Current                 | V <sub>CC</sub> = MAX., $\overline{CS}$ = 2.4 V, V <sub>OUT</sub> = 2.4 V<br>V <sub>CC</sub> = MAX., $\overline{CS}$ = 2.4 V, V <sub>OUT</sub> = 0.4 V          |      | < 1              | 30    | μA    |
| I <sub>SC</sub> | Output Short Circuit Current           | V <sub>CC</sub> = MAX., V <sub>OUT</sub> = 0.0 V  | −20  | −30              | −60   | mA    |
| I <sub>CC</sub> | Power Supply Current                   | V <sub>CC</sub> = MAX.  |      | 55               | 70    | mA    |
| V <sub>I</sub>  | Input Clamp Voltage                    | V <sub>CC</sub> = MIN., I <sub>IN</sub> = −18 mA  |      |                  | −1.5  | Volts |

Note 1. Typical Limits are at V<sub>CC</sub> = 5.0 V, 25°C ambient and maximum loading.

## SWITCHING CHARACTERISTICS OVER OPERATING RANGE (Unless Otherwise Noted)

| Parameters                           | Description  |            | T <sub>A</sub> =<br>25°C<br>Typ. | T <sub>A</sub> =<br>0°C to<br>75°C<br>Min. | T <sub>A</sub> =<br>0°C to<br>75°C<br>Max. | T <sub>A</sub> =<br>−55°C<br>to 125°C<br>Min. | T <sub>A</sub> =<br>−55°C<br>to 125°C<br>Max. | Units |
|--------------------------------------|--|------------|----------------------------------|--|--|---|---|-------|
| t <sub>PLH</sub> (A)                 | Delay from Address to Output                             | See Fig. 2 | 35                               | 15   | 45   | 10  | 55  | ns    |
| t <sub>PHL</sub> (A)                 |  |            |                                  |  |  |   |   |       |
| t <sub>PZH</sub> ( $\overline{CS}$ ) | Delay from Chip Select to Active Output and Correct Data | See Fig. 2 | 15                               | 5  | 25   | 5   | 30  | ns    |
| t <sub>PZL</sub> ( $\overline{CS}$ ) |  |            |                                  |  |  |   |   |       |
| t <sub>PHZ</sub> ( $\overline{CS}$ ) | Delay from Chip Select to Inactive Output                | See Fig. 2 | 15                               | 5  | 25   | 5   | 30  | ns    |
| t <sub>PLZ</sub> ( $\overline{CS}$ ) |  |            |                                  |  |  |   |   |       |
| t <sub>rec</sub> ( $\overline{WE}$ ) | Delay from Write Enable (HIGH) to Correct Output Data    | See Fig. 1 | 25                               |  | 45   |   | 55  | ns    |
| t <sub>PZH</sub> ( $\overline{WE}$ ) | Delay from Write Enable (HIGH) to Active Output          | See Fig. 1 |                                  | 5  |  | 5   |   | ns    |
| t <sub>PZL</sub> ( $\overline{WE}$ ) |  |            |                                  |  |  |   |   |       |
| t <sub>PHZ</sub> ( $\overline{WE}$ ) | Delay from Write Enable (LOW) to Inactive Output         | See Fig. 1 | 20                               |  | 30   |   | 40  | ns    |
| t <sub>PLZ</sub> ( $\overline{WE}$ ) |  |            |                                  |  |  |   |   |       |
| t <sub>s</sub> (A)                   | Set-up Time Address                                      | See Fig. 1 | 0                                | 0  |  | 5   |   | ns    |
| t <sub>h</sub> (A)                   | Hold Time Address  |            | 0                                | 0  |  | 5   |   | ns    |
| t <sub>s</sub> (DI)                  | Set-up Time Data Input                                   | See Fig. 1 | 20                               | 30   |  | 35  |   | ns    |
| t <sub>h</sub> (DI)                  | Hold Time Data Input                                     | See Fig. 1 | 0                                | 0  |  | 5   |   | ns    |
| t <sub>pw</sub> ( $\overline{WE}$ )  | Write Enable Pulse Width                                 | See Fig. 1 | 20                               | 30   |  | 35  |   | ns    |

### Am27LS00/Am27LS01 LOADING RULES (In TTL Unit Loads)

| Input/Output    | Pin No.'s | Input<br>Unit Load | Fan-out        |               |
|-----------------|-----------|--------------------|----------------|---------------|
|                 |           |                    | Output<br>HIGH | Output<br>LOW |
| A <sub>1</sub>  | 1         | 0.5                | —              | —             |
| A <sub>0</sub>  | 2         | 0.5                | —              | —             |
| $\overline{CS}$ | 3         | 0.5                | —              | —             |
| $\overline{CS}$ | 4         | 0.5                | —              | —             |
| $\overline{CS}$ | 5         | 0.5                | —              | —             |
| DO (Note)       | 6         | —                  | 50/65          | 10            |
| A <sub>4</sub>  | 7         | 0.5                | —              | —             |
| GND             | 8         | —                  | —              | —             |
| A <sub>5</sub>  | 9         | 0.5                | —              | —             |
| A <sub>6</sub>  | 10        | 0.5                | —              | —             |
| A <sub>7</sub>  | 11        | 0.5                | —              | —             |
| $\overline{WE}$ | 12        | 0.5                | —              | —             |
| DI              | 13        | 0.5                | —              | —             |
| A <sub>3</sub>  | 14        | 0.5                | —              | —             |
| A <sub>2</sub>  | 15        | 0.5                | —              | —             |
| V <sub>CC</sub> | 16        | —                  | —              | —             |

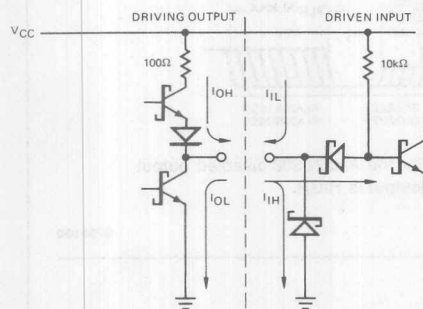
Note: Am27LS01 has open collector output.  
A Standard TTL Unit Load is defined as 40 $\mu$ A measured at 2.4V HIGH and —1.6mA measured at 0.4V LOW.

### Am27LS00/Am27LS01 LOADING RULES (In Low Power Schottky Unit Loads)

| Input/Output    | Pin No.'s | Input<br>Unit Load | Fan-out        |               |
|-----------------|-----------|--------------------|----------------|---------------|
|                 |           |                    | Output<br>HIGH | Output<br>LOW |
| A <sub>1</sub>  | 1         | 2.2                | —              | —             |
| A <sub>0</sub>  | 2         | 2.2                | —              | —             |
| $\overline{CS}$ | 3         | 2.2                | —              | —             |
| $\overline{CS}$ | 4         | 2.2                | —              | —             |
| $\overline{CS}$ | 5         | 2.2                | —              | —             |
| DO (Note)       | 6         | —                  | 100/130        | 44            |
| A <sub>4</sub>  | 7         | 2.2                | —              | —             |
| GND             | 8         | —                  | —              | —             |
| A <sub>5</sub>  | 9         | 2.2                | —              | —             |
| A <sub>6</sub>  | 10        | 2.2                | —              | —             |
| A <sub>7</sub>  | 11        | 2.2                | —              | —             |
| $\overline{WE}$ | 12        | 2.2                | —              | —             |
| DI              | 13        | 2.2                | —              | —             |
| A <sub>3</sub>  | 14        | 2.2                | —              | —             |
| A <sub>2</sub>  | 15        | 2.2                | —              | —             |
| V <sub>CC</sub> | 16        | —                  | —              | —             |

Note: Am27LS01 has open collector output.  
A Low Power Schottky TTL Unit Load is defined as 20 $\mu$ A measured at 2.7V HIGH and —0.36mA measured at 0.4V LOW.

### INPUT/OUTPUT CURRENT INTERFACE CONDITIONS



Note: Actual current flow direction shown.

### TRUTH TABLE

| Inputs          |                 |    | Output                   | Mode         |
|-----------------|-----------------|----|--------------------------|--------------|
| $\overline{CS}$ | $\overline{WE}$ | DI | $\overline{DO}(t_{n+1})$ |              |
| H               | X               | X  | OFF                      | No Selection |
| L               | L               | L  | OFF                      | Write '0'    |
| L               | L               | H  | OFF                      | Write '1'    |
| L               | H               | X  | $\overline{DI}(t_n)$     | Read         |

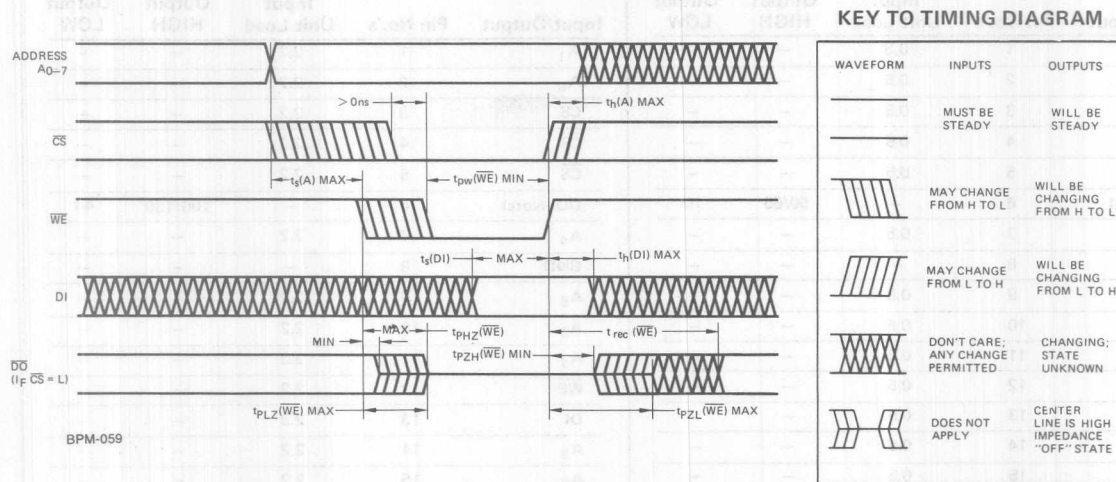
H = HIGH Voltage Level

L = LOW Voltage Level

X = Don't Care

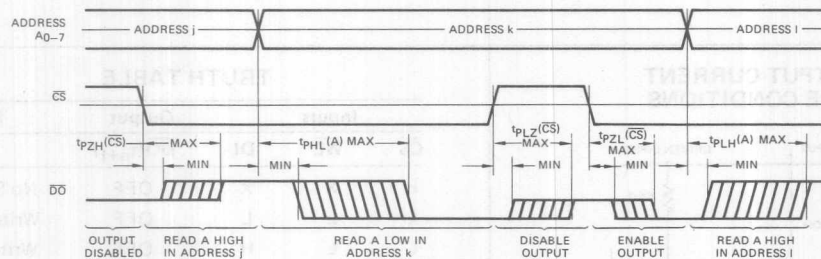
OFF = Floating output level is determined by external circuitry connected to the output.

## SWITCHING WAVEFORMS



**Write Cycle Timing.** The cycle is initiated by an address change. After  $t_s(A)$  max, the write enable may begin. The chip select must also be LOW for writing. Following the write pulse,  $t_h(A)$  max must be allowed before the address may be changed again. The output will be inactive (floating for the Am27LS00) while the write enable is LOW. Ordinarily, the chip select should be LOW during the entire write pulse.

Figure 1

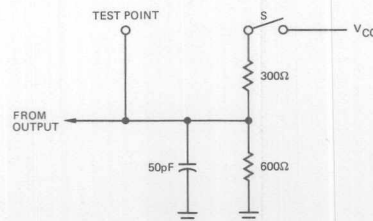


Switching delays from address and chip select inputs to the data output. For the Am27LS00 a disabled output is "OFF," represented by a single center line. For the Am27LS01, a disabled output is HIGH.

Figure 2

BPM-060

## TEST LOAD



Note: All measurements at 1.5V

BPM-061

S is closed for all tests except for Am27LS00 tests in which the output switches between an active HIGH level and a HIGH impedance state.



## OUTPUT LOADING RULES

The Am27LS01 has an open collector output. The outputs of several memories may be tied together and the common line connected through a pull-up resistor to  $V_{CC}$ . The common line will go LOW if and only if one of the Am27LS01 outputs connected to it goes LOW, i.e., is enabled and reading a LOW. The HIGH state is established by the pull-up resistor. The value of the resistor is limited by two equations:

$$R(\min) = \frac{V_{CC}(\max) - 0.4}{16 - i(1.6)} \quad i = \text{number of TTL inputs driven}$$

$$R(\max) = \frac{V_{CC}(\min) - 2.4}{0.03n + 0.04i} \quad n = \text{number of Am27LS01 outputs connected together}$$

For highest speed, use the minimum R; for lowest power, use the maximum R.

The Am27LS00 has active circuitry to establish both the HIGH and LOW logic levels and requires no pull-up resistor. Up to 64 Am27LS00 outputs can be connected together.

## DEFINITIONS OF TERMS

## SUBSCRIPT TERMS:

**H** HIGH, applying to a HIGH-signal level or when used with  $V_{CC}$  to indicate high  $V_{CC}$  value.

**I** Input.

**L** LOW, applying to a LOW signal level or when used with  $V_{CC}$  to indicate low  $V_{CC}$  value.

**O** Output.

**X** Unknown or don't care state

**Z** OFF, applying to the third high impedance state of the output.

## FUNCTIONAL TERMS:

**Three State** A three state output can exist in three possible states: output LOW sinking current, output HIGH sourcing current, and output floating where the output level is determined by external circuitry connected to the output. This three state output allows AND tying of memory outputs for memory expansion and still keeps the inherent high speed of active pull-up circuitry.

**Fully Decoded** In a fully decoded memory every possible address combination of logic HIGH's and LOW's uniquely selects a memory word. This form of decoding requires no additional special purpose decoders for system operation and is the most efficient in terms of address inputs required and overall system speed.

**Fan-Out** The logic HIGH or LOW output drive capability in terms of Input Unit Loads.

**Input Unit Load** One  $T^2L$  gate input load.

**SWITCHING TERMS:** (All switching times are measured at the 1.5 V logic level).

**$t_{PXH}$**  The delay from a logic level change at an input to a HIGH level on an output.

**$t_{PXL}$**  The delay from a logic level change at an input to a LOW level on an output.

**$t_{PXZ}$**  The delay from a logic level change at an input to a high impedance state on a three state output. Measured with a resistor pull-down or pull-up.

**$t_{PXX}(A)$**  The delay from an address input to the memory output.

**$t_{PXX}(\overline{CS})$**  The delay from a chip select input to the memory output.

**$t_{PXZ}(\overline{WE})$**  The delay from a HIGH-to-LOW transition on the write enable to a high impedance level on the memory output.

**$t_{PZX}(\overline{WE})$**  The delay from a LOW-to-HIGH transition on the write enable to an active level on the memory output.

**$t_{pw}(\overline{WE})$**  The shortest LOW pulse on the write enable input which is guaranteed to cause the memory to write. Pulses shorter than  $t_{pw}(\overline{WE})$  min. may or may not cause a write to occur.

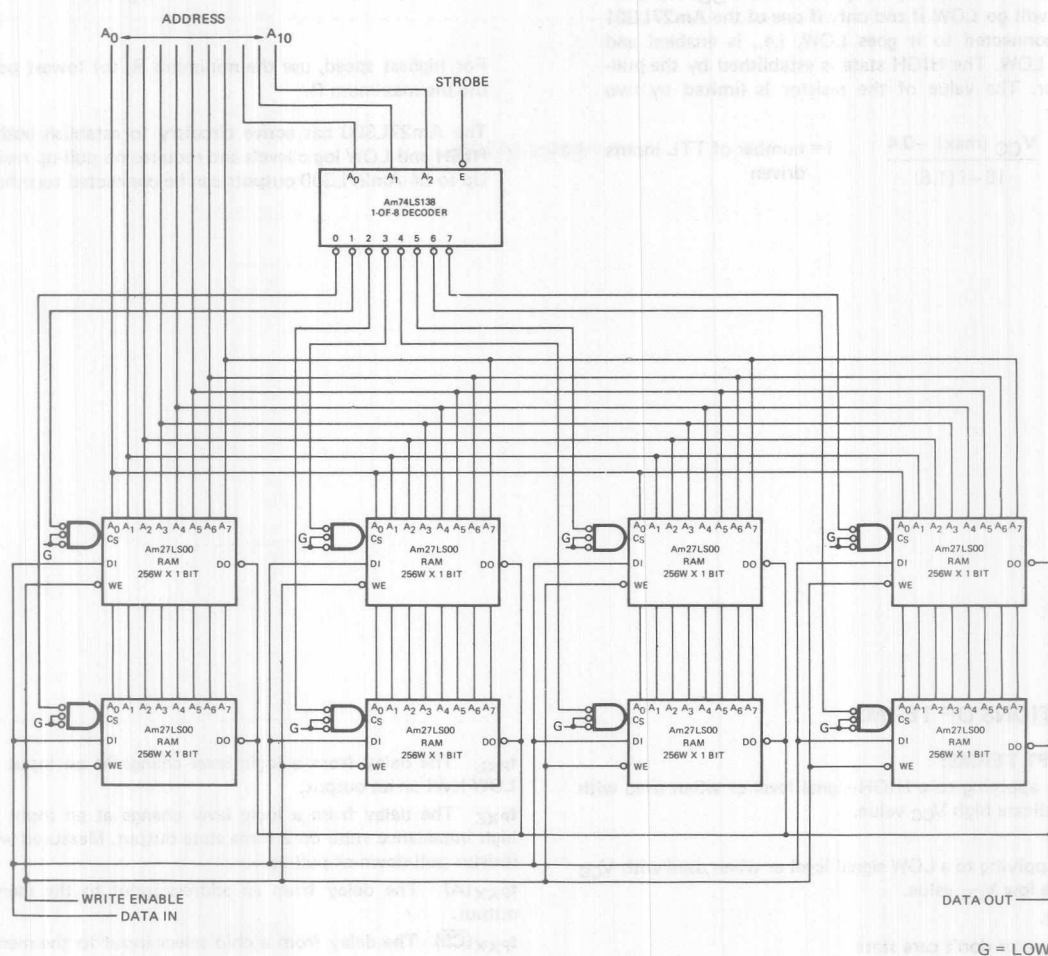
**$t_s(A)$**  The set-up time of the address inputs relative to the HIGH-to-LOW edge of the write pulse. This is the time required for internal address decoding to settle. To avoid writing in spurious addresses, a stable address should be applied to the address inputs at least  $t_s(A)$  max. before the write pulse begins.

**$t_h(A)$**  The address hold time. This parameter is similar to  $t_s(A)$  but is measured relative to the end of the write pulse rather than the beginning. A stable address should be maintained on the address inputs for  $t_h(A)$  max. after the write pulse has ended in order to prevent writing in spurious addresses.

**$t_s(DI)$**  Data set-up time. The time prior to the end of the write pulse during which data must be stable to be correctly written into the memory.

**$t_h(DI)$**  Data hold time. The time following the end of the write pulse during which data must not be changed.

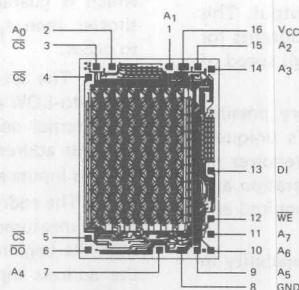
## APPLICATION



2048 WORD x 1-BIT MEMORY

BPM-062

## Metallization and Pad Layout



DIE SIZE : 0.084" X 0.121"

# Am27S02 • 27S03

## 64-Bit Random Access Memory

### Distinctive Characteristics

- Fully decoded 16-word x 4-bit Schottky technology high-speed RAM.
- Access time typically 22ns.
- Available with three-state outputs (Am27S03) or with open collector outputs (Am27S02).
- Pin compatible high speed replacement for 3101, 93403, and 7489 (use Am27S02) and for DM 75/8599 (use Am27S03).
- 100% reliability assurance testing in compliance with MIL-STD-883.

### FUNCTIONAL DESCRIPTION

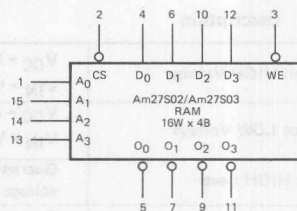
The Am27S02(Am3101A) and Am27S03 are 64-bit RAMs built using Schottky diode clamped transistors and are ideal for use in scratch pad and high-speed buffer memory applications. Each memory is organized as a fully decoded 16-word memory of 4 bits per word. Easy memory expansion is provided by an active LOW chip select (CS) input and open collector OR tieable outputs (Am3101A/Am27S02) or three-state outputs (Am27S03). Chip selection for large memory systems can be controlled by active LOW output decoders such as the Am9301 and Am9311.

An active LOW Write line  $\overline{WE}$  controls the writing/reading operation of the memory. When the chip select and write lines are LOW the information on the four data inputs  $D_0$  to  $D_3$  is written into the addressed memory word.

Reading is performed with the chip select line LOW and the write line HIGH. The information stored in the addressed word is read out on the four inverting outputs  $\overline{O}_0$  to  $\overline{O}_3$ .

During the writing operation or when the chip select line is HIGH the four outputs of the memory go to an inactive high impedance state.

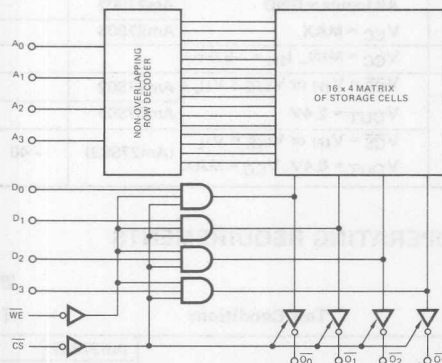
### LOGIC SYMBOL



$V_{CC}$  = Pin 16  
GND = Pin 8

BPM-063

### LOGIC BLOCK DIAGRAM



BPM-064

### ORDERING INFORMATION

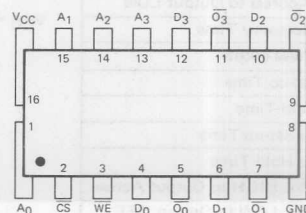
#### Open Collector Outputs

| Package Type      | Temperature Range | Order Number        |
|-------------------|-------------------|---------------------|
| Molded DIP        | 0°C to 75°C       | AM27S02PC or P3101A |
| Hermetic DIP      | 0°C to 75°C       | AM27S02DC or C3101A |
| Hermetic DIP      | -55°C to +125°C   | AM27S02DM           |
| Hermetic Flat Pak | -55°C to +125°C   | AM27S02FM           |

#### Three-State Outputs

|                   |                 |           |
|-------------------|-----------------|-----------|
| Molded DIP        | 0°C to +75°C    | AM27S03PC |
| Hermetic DIP      | 0°C to +75°C    | AM27S03DC |
| Hermetic DIP      | -55°C to +125°C | AM27S03DM |
| Hermetic Flat Pak | -55°C to +125°C | AM27S03FM |

### CONNECTION DIAGRAM Top View



Note: Pin 1 is marked for orientation.

BPM-065

## Am27S02 • Am27S03

### MAXIMUM RATINGS (Above which the useful life may be impaired)

|  |                                |
|--|--------------------------------|
| Storage Temperature                                  | −65°C to +150°C                |
| Temperature (Ambient) Under Bias                     | −55°C to +125°C                |
| Supply Voltage to Ground Potential (Pin 16 to Pin 8) | −0.5V to +7V                   |
| DC Voltage Applied to Outputs for High Output State  | −0.5V to +V <sub>CC</sub> max. |
| DC Input Voltage                                     | −0.5V to +5.5V                 |
| Output Current, Into Outputs                         | 100mA                          |
| DC Input Current                                     | −30mA to +5.0mA                |

### ELECTRICAL CHARACTERISTICS OVER OPERATING TEMPERATURE RANGE (Unless Otherwise Noted)

Am27S02XC, Am27S03XC

T<sub>A</sub> = 0°C to +75°C

V<sub>CC</sub> = 5.0V ±5%

Am27S02XM, Am27S03XM

T<sub>A</sub> = −55°C to +125°C

V<sub>CC</sub> = 5.0V ±10%

| Parameters                        | Description                  | Test Conditions   | Min. | Typ.<br>(Note 1) | Max. | Units |
|-----------------------------------|------------------------------|---|------|------------------|------|-------|
| V <sub>OH</sub><br>(Am27S03 only) | Output HIGH Voltage          | V <sub>CC</sub> = MIN., I <sub>OH</sub> = −0.8mA<br>V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>                  | 2.4  | 3.6              |      | Volts |
| V <sub>OL</sub>                   | Output LOW Voltage           | V <sub>CC</sub> = MIN.,<br>V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>   |      | 0.3              | 0.45 | Volts |
| *V <sub>IH</sub>                  | Input HIGH Level             | Guaranteed input logical HIGH voltage for all inputs  | 2.0  |                  |      | Volts |
| *V <sub>IL</sub>                  | Input LOW Level              | Guaranteed input logical LOW voltage for all inputs   |      |                  | 0.8  | Volts |
| I <sub>IL</sub>                   | Input LOW Current            | V <sub>CC</sub> = MAX.,<br>V <sub>IN</sub> = 0.45V  |      | .030             | 0.25 | mA    |
| I <sub>IH</sub>                   | Input HIGH Current           | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 2.4V  |      | .060             | 0.25 | μA    |
| I <sub>SC</sub><br>(Am27S03 only) | Output Short Circuit Current | V <sub>CC</sub> = MAX., V <sub>OUT</sub> = 0.0V   | −12  | −35              | −90  | mA    |
| I <sub>CC</sub>                   | Power Supply Current         | All inputs = GND<br>V <sub>CC</sub> = MAX.  |      | 76               | 105  | mA    |
| V <sub>C</sub>                    | Input Clamp Voltage          | V <sub>CC</sub> = MIN., I <sub>IN</sub> = −5.0mA  |      |                  | −1.0 | Volts |
| I <sub>CEX</sub>                  | Output Leakage Current       | V <sub>CS</sub> = V <sub>IH</sub> or V <sub>WE</sub> = V <sub>IL</sub><br>V <sub>OUT</sub> = 2.4V                         |      |                  | 100  | μA    |
|                                   |                              | V <sub>CS</sub> = V <sub>IH</sub> or V <sub>WE</sub> = V <sub>IL</sub><br>V <sub>OUT</sub> = 0.4V, V <sub>CC</sub> = MAX. |      |                  | 40   | μA    |
|                                   |                              | (Am27S03)   | −40  |                  |      | μA    |

Note 1. Typical limits are at V<sub>CC</sub> = 5.0V and T<sub>A</sub> = 25°C

### SWITCHING CHARACTERISTICS AND OPERATING REQUIREMENTS

| Parameters                                  | Description                             | Test Conditions  | 25°C          | T <sub>A</sub> = 0° to 75°C |      | Units |
|---|---|--|---------------|-----------------------------|------|-------|
|   |   |  | Typ.          | Min.                        | Max. |       |
| t <sub>pd±</sub> ( $\overline{\text{CS}}$ ) | Delay Chip Select to Output HIGH or LOW | V <sub>CC</sub> = 5.0V, C <sub>L</sub> = 30 pF, R <sub>L</sub> = 300Ω V <sub>CC</sub><br>and<br>600Ω to GND (16mA Load)<br>measure at 1.5V | Am27S02<br>12 | 5                           | 17   | ns    |
|   |   |  | Am27S03<br>15 |                             | 25   |       |
| t <sub>pdz</sub> ( $\overline{\text{CS}}$ ) | Delay Chip Select HIGH to Output OFF    |  | 12            |                             | 20   | ns    |
| t <sub>pd+</sub> (A)                        | Delay Address to Output HIGH            |  | 22            | 10                          | 35   | ns    |
| t <sub>pd−</sub> (A)                        | Delay Address to Output LOW             |  | 22            | 10                          | 35   | ns    |
| t <sub>rec</sub> (WE)                       | Write Recovery Time                     |  |               |                             | 35   | ns    |
| *t <sub>pw</sub> (WE)                       | Write Pulse Width                       |  |               | 25                          |      | ns    |
| *t <sub>s</sub> (D)                         | Data Set-up Time                        |  |               | 25                          |      | ns    |
| *t <sub>h</sub> (D)                         | Data Hold Time                          |  |               | 0                           |      | ns    |
| *t <sub>s</sub> (A)                         | Address Set-up Time                     |  |               | 0                           |      | ns    |
| *t <sub>h</sub> (A)                         | Address Hold Time                       |  |               | 0                           |      | ns    |
| t <sub>pd±</sub> (WE)                       | Delay WE HIGH to Output Active          |  | 12            |                             | 25   | ns    |
| t <sub>pdz</sub> (WE)                       | Delay WE LOW to Output OFF              |  | 12            |                             | 25   | ns    |

\*System requirement. Parameters preceded by an asterisk are specified as system forcing requirements rather than device characteristics. In general, minimum system requirements result from maximum device characteristics. Typical values are not meaningful for system requirements.

## DEFINITION OF TERMS

## FUNCTIONAL TERMS

**$\overline{CS}$**  Active LOW chip select input. When the chip select is LOW data can be read from or written into the memory.

**$D_i$**  The data inputs of the memory,  $i = 1 - 4$

**$O_i$**  The data outputs of the memory,  $i = 1 - 4$

**$O_i(t_n)$**  The state of output  $i$  at time  $n$ .

**$D_i(t_{n-x})$**  The state of the  $D_i$  input at time  $t_{n-x}$ , where  $t_{n-x}$  is the time of the last write operation into a given address.

**$\overline{WE}$**  Active LOW Write Enable. When the write enable is LOW, data on the data inputs is written into the addressed memory location. When  $\overline{WE}$  is HIGH data is read from the addressed location and appears, inverted, at the  $\overline{O}$  outputs.

**UNIT LOAD** A TTL input unit load is defined as  $-1.6\text{mA}$  at  $0.4\text{V}$  (LOW state) and  $40\mu\text{A}$  at  $2.4\text{V}$  (HIGH state).

## SWITCHING TERMS

**$t_{pd\pm}(\overline{CS})$**  The delay from the chip select input going LOW to the output going active.

**$t_{pdz}(\overline{CS})$**  The delay from the chip select going HIGH to the output assuming an inactive high impedance level.

**$t_{pd\pm}(A)$**  The delay from a change on the address inputs to a correct HIGH ( $t_{pd+}$ ) or LOW ( $t_{pd-}$ ) level on the outputs. Access time.

**$t_{rec}(\overline{WE})$**  Write recovery time. The delay from a LOW-to-HIGH transition on the write enable to the correct data on the outputs of the memory. This is the time required between the

end of the write operation and a read operation in the same address.

**$*t_{pw}(\overline{WE})$**  Minimum write pulse width. The LOW time on the write enable input required to cause a write.

**$*t_s(D), *t_h(D)$**  Data set-up and hold times. The time, relative to the end of the write pulse (LOW-to-HIGH edge) after which the data on the data inputs will not be written into the memory. To ensure writing the correct data, the data must be present before  $*t_s(D)$  min. and must remain until after  $*t_h(D)$  min.

**$*t_s(A)$**  Address set-up time. The time prior to the start of the write pulse (HIGH-to-LOW edge) at which the correct write address must be on the address inputs. An address change later than  $*t_s(A)$  max. may cause writing in two addresses.

**$*t_h(A)$**  Address hold time. The time following the end of the write pulse (LOW-to-HIGH transition) at which a new address may be applied. An address change earlier than  $*t_h(A)$  min. may cause writing into two addresses.

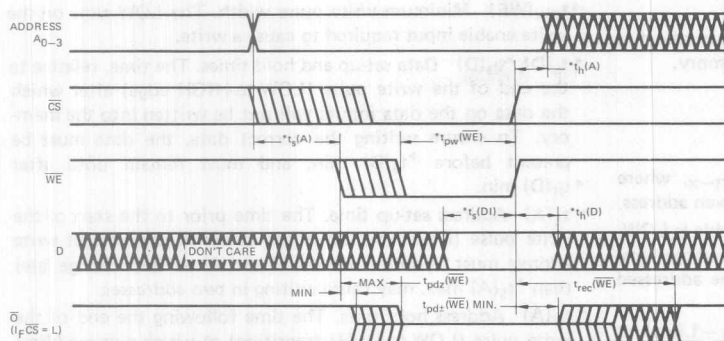
**$t_{pd\pm}(\overline{WE})$**  The delay from a LOW-to-HIGH transition of the write enable to an active (but not necessarily correct) state on the data outputs. The correct state will be present after the write recovery time has elapsed.

**$t_{pdo}(\overline{WE})$**  The delay from a HIGH-to-LOW transition on the write enable to a high impedance level on the data outputs, if the chip is selected.

\*System requirement. Parameters preceded by an asterisk are specified as system forcing requirements rather than device characteristics. In general, minimum system requirements result from maximum device characteristics. Typical values are not meaningful for system requirements.



## SWITCHING WAVEFORMS

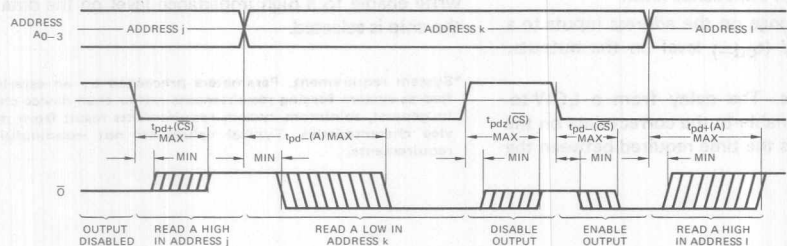


BPM-066

## KEY TO TIMING DIAGRAM

| WAVEFORM | INPUTS                           | OUTPUTS                                   |
|----------|----------------------------------|---|
|          | MUST BE STEADY                   | WILL BE STEADY                            |
|          | MAY CHANGE FROM H TO L           | WILL BE CHANGING FROM H TO L              |
|          | MAY CHANGE FROM L TO H           | WILL BE CHANGING FROM L TO H              |
|          | DON'T CARE, ANY CHANGE PERMITTED | CHANGING, STATE UNKNOWN                   |
|          | DOES NOT APPLY                   | CENTER LINE IS HIGH IMPEDANCE "OFF" STATE |

Write Cycle Timing. The cycle is initiated by an address change. After  $t_s(A)$  min., the write enable may begin. The chip select must also be LOW for writing. Following the write pulse,  $t_h(A)$  min. must be allowed before the address may be changed again. The output will be inactive (floating for the Am27S03) while the write enable is LOW. The three parameters  $t_s(A)$ ,  $t_h(A)$  and  $t_{pw}(WE)$  apply to the condition CS LOW AND WE LOW.

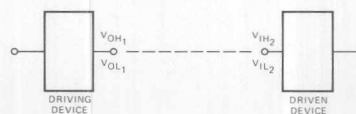
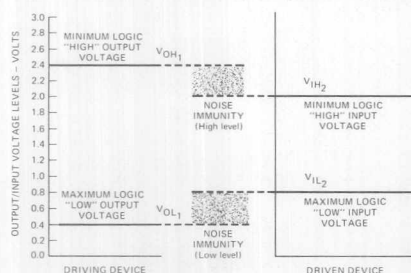


Switching delays from address and chip select inputs to the data output. For the Am27S03 disabled output is "OFF", represented by a single center line. For the Am27S02, a disabled output is HIGH.

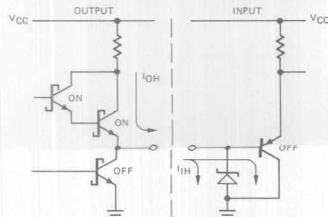
BPM-067

## INPUT/OUTPUT INTERFACE CONDITIONS

## Voltage Interface Conditions – LOW &amp; HIGH

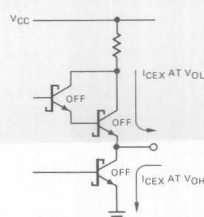


## Current Conditions – HIGH State



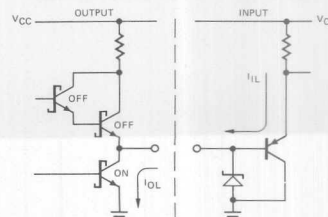
Note: Am27S02 is open collector

## Currents Conditions – OFF State



Note: Am27S02 is open collector

## Current Conditions – LOW State



BPM-068

## USER NOTES

1. The Am27S03 output has active circuitry for both logic levels and requires no external pull-up resistor.
2. For a good DC noise margin with the Am3101A/27S02 a pull-up resistor can be used. Limits of R in kΩ are given by

$$\frac{V_{CC} - V_{OH \text{ required}}}{nI_{CEX} + NI_{IH}} > R_L > \frac{V_{CC} - V_{OL \text{ required}}}{I_{OL} - NI_{IL}}$$

Where n is number of OR tied outputs

N is the number of TTL units loads driven.

3. Address and data lines can be interchanged within their respective groups for ease of P. C. layout without effecting device operation.
4. Since for a given pattern on the address lines reading and writing are performed on the same actual memory word, the address lines can be driven by any mixture of assertion or negation of the variables making up the address field.

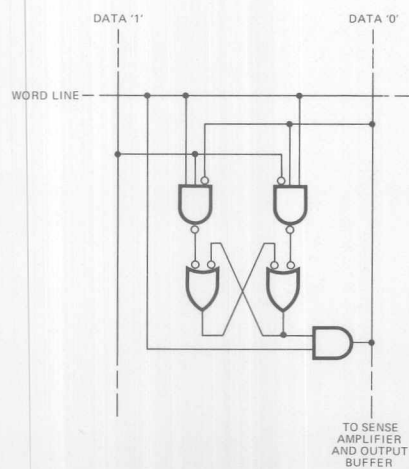
## Am3101A LOADING RULES (In TTL Loads)

| Input/Output     | Pin No.'s | Input Loading | Output Drive (Am27S03) |     |
|------------------|-----------|---------------|------------------------|-----|
|                  |           |               | HIGH                   | LOW |
| A <sub>0</sub>   | 1         | .16           | —                      | —   |
| $\overline{CS}$  | 2         | .16           | —                      | —   |
| $\overline{WE}$  | 3         | .16           | —                      | —   |
| D <sub>0</sub>   | 4         | .16           | —                      | —   |
| $\overline{O_0}$ | 5         | —             | 20                     | 10  |
| D <sub>1</sub>   | 6         | .16           | —                      | —   |
| $\overline{O_1}$ | 7         | —             | 20                     | 10  |
| GND              | 8         | —             | —                      | —   |
| $\overline{O_2}$ | 9         | —             | 20                     | 10  |
| D <sub>2</sub>   | 10        | .16           | —                      | —   |
| $\overline{O_3}$ | 11        | —             | 20                     | 10  |
| D <sub>3</sub>   | 12        | .16           | —                      | —   |
| A <sub>3</sub>   | 13        | .16           | —                      | —   |
| A <sub>2</sub>   | 14        | .16           | —                      | —   |
| A <sub>1</sub>   | 15        | .16           | —                      | —   |
| V <sub>CC</sub>  | 16        | —             | —                      | —   |

A TTL unit load is —1.6mA at 0.4V and 40μA at 2.0V.

The Am27S02 has open collector outputs; the output drive in the HIGH state is determined by an external pull-up resistor.

## BASIC MEMORY CELL



BPM-069

## TRUTH TABLE

| INPUTS          |                 | OUTPUTS        |                                    | MODE         |
|-----------------|-----------------|----------------|------------------------------------|--------------|
| $\overline{CS}$ | $\overline{WE}$ | D <sub>i</sub> | $\overline{O_i}(t_n)$              |              |
| H               | L               | L              | Off                                | No Selection |
| H               | L               | H              | Off                                | No Selection |
| H               | H               | X              | Off                                | No Selection |
| L               | L               | L              | Off                                | Write '0'    |
| L               | L               | H              | Off                                | Write '1'    |
| L               | H               | X              | D <sub>i</sub> (t <sub>n</sub> —x) | Read         |

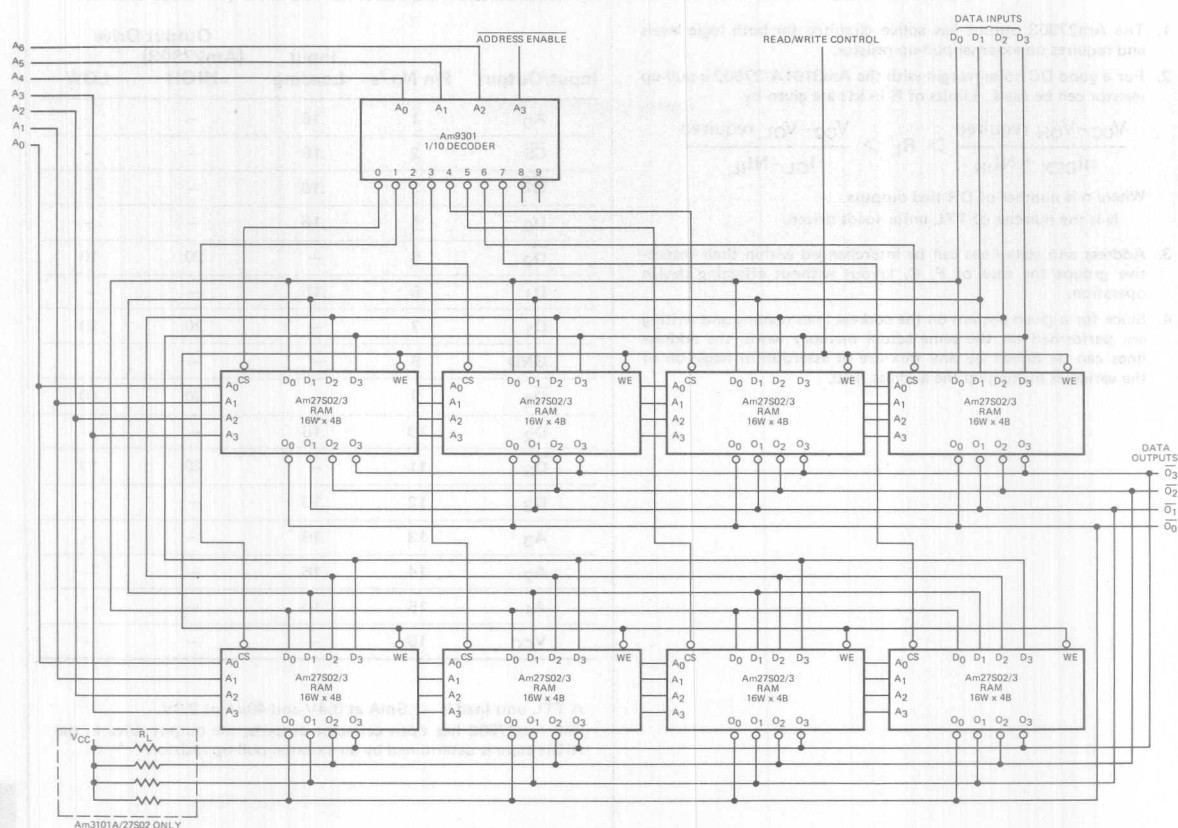
H = HIGH Voltage Level

L = LOW Voltage Level

OFF = HIGH Impedance

Note: The Am27S02 output is at a high impedance level at all times except when reading a LOW.

## Am3101A/27S02/27S03 APPLICATION



128 WORD x 4-BIT MEMORY

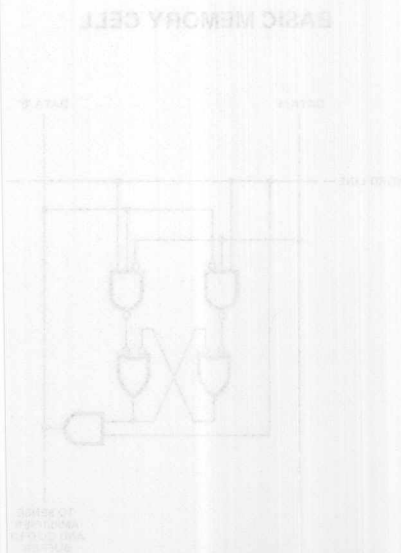
BPM-070

TRUTH TABLE

| OUTPUTS | DATA | WE | CS | MODE  |
|---------|------|----|----|-------|
| 0H      | 0    | L  | H  | Read  |
| 0H      | 1    | L  | H  | Read  |
| 0H      | X    | H  | H  | Read  |
| 0H      | 0    | L  | L  | Write |
| 0H      | 1    | L  | L  | Write |
| 0H      | X    | H  | L  | Write |

H = HIGH impedance  
L = LOW impedance  
X = HIGH impedance

NOT: The Am3101A/27S02/3 output is a high impedance level.  
At test, the output is a high impedance level.



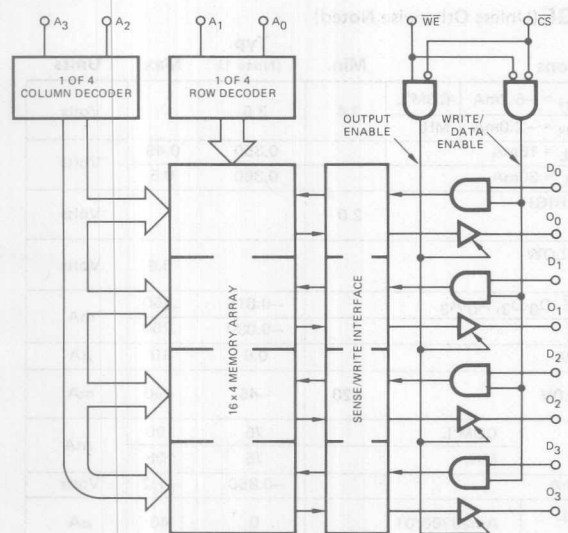
# Am27S06 • Am27S07

## Non-Inverting Schottky 64-Bit Random Access Memories

### DISTINCTIVE CHARACTERISTICS

- Fully decoded 16-word x 4-bit Low-power Schottky RAMs
- Ultra-high speed: Address access time typically 15ns
- Low Power:  $I_{CC}$  typically 75mA
- Internal ECL circuitry for optimum speed/power performance over voltage and temperature
- Output preconditioned during write to eliminate write recovery glitch
- Available with three-state outputs (Am27S07) or with open collector outputs (Am27S06)
- 100% reliability assurance testing in compliance with MIL-STD-883
- Electrically tested and optically inspected die for the assemblers of hybrid products

### LOGIC BLOCK DIAGRAM



MPR-239

### ORDERING INFORMATION

#### Open Collector Outputs

| Package Type      | Temperature Range | Order Number |
|-------------------|-------------------|--------------|
| Molded DIP        | 0°C to +75°C      | AM27S06APC   |
| Hermetic DIP      | 0°C to +75°C      | AM27S06ADC   |
| Hermetic DIP      | -55°C to +125°C   | AM27S06ADM   |
| Hermetic Flat Pak | -55°C to +125°C   | AM27S06AFM   |

#### Three-State Outputs

|                   |                 |            |
|-------------------|-----------------|------------|
| Molded DIP        | 0°C to +75°C    | AM27S07APC |
| Hermetic DIP      | 0°C to +75°C    | AM27S07ADC |
| Hermetic DIP      | -55°C to +125°C | AM27S07ADM |
| Hermetic Flat Pak | -55°C to +125°C | AM27S07AFM |

### FUNCTIONAL DESCRIPTION

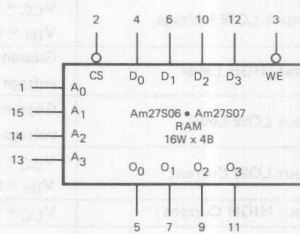
The Am27S06 and Am27S07 are 64-bit RAMs built using Schottky diode clamped transistors in conjunction with internal ECL circuitry and are ideal for use in scratch pad and high-speed buffer memory applications. Each memory is organized as a fully decoded 16-word memory of 4 bits per word. Easy memory expansion is provided by an active LOW chip select (CS) input and open collector OR tieable outputs (Am27S06) or three-state outputs (Am27S07). Chip selection for large memory systems can be controlled by active LOW output decoders such as the Am74S138.

An active LOW Write line  $\overline{WE}$  controls the writing/reading operation of the memory. When the chip select and write lines are LOW the information on the four data inputs  $D_0$  to  $D_3$  is written into the addressed memory word and preconditions the output circuitry so that true data is present at the outputs when the write cycle is complete. This preconditioning operation insures minimum write recovery times by eliminating the "write recovery glitch".

Reading is performed with the chip select line LOW and the write line HIGH. The information stored in the addressed word is read out on the four non-inverting outputs  $O_0$  to  $O_3$ .

During the writing operation or when the chip select line is HIGH the four outputs of the memory go to an inactive high impedance state.

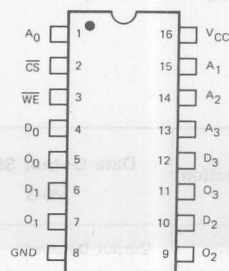
### LOGIC SYMBOL



$V_{CC}$  = Pin 16  
GND = Pin 8

MPR-240

### CONNECTION DIAGRAM Top View



Note: Pin 1 is marked for orientation.

MPR-241

Am27S06 • Am27S07

MAXIMUM RATINGS (Above which the useful life may be impaired)

|  |                               |
|--|-------------------------------|
| Storage Temperature                                  | −65°C to +150°C               |
| Temperature (Ambient) Under Bias                     | −55°C to +125°C               |
| Supply Voltage to Ground Potential (Pin 16 to Pin 8) | −0.5V to +7V                  |
| DC Voltage Applied to Outputs for High Output State  | −0.5V to V <sub>CC</sub> max. |
| DC Input Voltage                                     | −0.5V to +5.5V                |
| Output Current, Into Outputs                         | 100mA                         |
| DC Input Current                                     | −30mA to +5.0mA               |

OPERATING RANGE

| Part No.   | V <sub>CC</sub> | Ambient Temperature |
|--|-----------------|---------------------|
| Commercial Grade<br>Am27S06APC, DC<br>Am27S07APC, DC | 5.0V ±5%        | 0°C to +75°C        |
| Military Grade<br>Am27S06ADM, FM<br>Am27S07ADM, FM   | 5.0V ±10%       | −55°C to +125°C     |

ELECTRICAL CHARACTERISTICS OVER OPERATING RANGE (Unless Otherwise Noted)

| Parameters                        |                              | Description   |   | D. C.        |     | Test Conditions  |              | Min. | Typ.<br>(Note 1) | Max.  | Units |
|-----------------------------------|------------------------------|---|---|--------------|-----|------------------|--------------|------|------------------|-------|-------|
| V <sub>OH</sub><br>(Am27S07 Only) | Output HIGH Voltage          | V <sub>CC</sub> = MIN,<br>V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>                    | I <sub>OH</sub> = −5.2mA<br>I <sub>OH</sub> = −2.0mA                      | COM*L<br>MIL | 2.4 | 3.6              |              |      |                  | Volts |       |
| V <sub>OL</sub>                   | Output LOW Voltage           | V <sub>CC</sub> = MIN.,<br>V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>                   | I <sub>OL</sub> = 16mA<br>I <sub>OL</sub> = 20mA                          |              |     | 0.350<br>0.380   | 0.45<br>0.5  |      |                  | Volts |       |
| V <sub>IH</sub>                   | Input HIGH Level             | Guaranteed input logical HIGH voltage for all inputs  |   |              | 2.0 |                  |              |      |                  | Volts |       |
| V <sub>IL</sub>                   | Input LOW Level              | Guaranteed input logical LOW voltage for all inputs   |   |              |     |                  |              | 0.8  |                  | Volts |       |
| I <sub>IL</sub>                   | Input LOW Current            | V <sub>CC</sub> = MAX.,<br>V <sub>IN</sub> = 0.40V  | WE, D <sub>0</sub> -D <sub>3</sub> , A <sub>0</sub> -A <sub>3</sub><br>CS |              |     | −0.015<br>−0.030 | .250<br>.250 |      |                  | mA    |       |
| I <sub>IH</sub>                   | Input HIGH Current           | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 2.4V  |   |              |     | 0.0              | 10           |      |                  | μA    |       |
| I <sub>SC</sub><br>(Am29701 Only) | Output Short Circuit Current | V <sub>CC</sub> = MAX., V <sub>OUT</sub> = 0.0V   |   |              | −20 | −45              | −90          |      |                  | mA    |       |
| I <sub>CC</sub>                   | Power Supply Current         | All inputs = GND<br>V <sub>CC</sub> = MAX.  | COM*L<br>MIL  |              |     | 75<br>75         | 100<br>105   |      |                  | mA    |       |
| V <sub>C</sub>                    | Input Clamp Voltage          | V <sub>CC</sub> = MIN., I <sub>IN</sub> = −18mA   |   |              |     | −0.850           | −1.2         |      |                  | Volts |       |
| I <sub>CEX</sub>                  | Output Leakage Current       | VCS = V <sub>IH</sub> or VWE = V <sub>IL</sub><br>V <sub>OUT</sub> = 2.4V                         | Am29700/01  |              |     | 0                | 40           |      |                  | μA    |       |
|                                   |                              | VCS = V <sub>IH</sub> or VWE = V <sub>IL</sub><br>V <sub>OUT</sub> = 0.4V, V <sub>CC</sub> = MAX. | Am29701   |              | −40 | 0                |              |      | μA               |       |       |

Note 1. Typical limits are at V<sub>CC</sub> = 5.0V and T<sub>A</sub> = 25°C.

FUNCTION TABLE

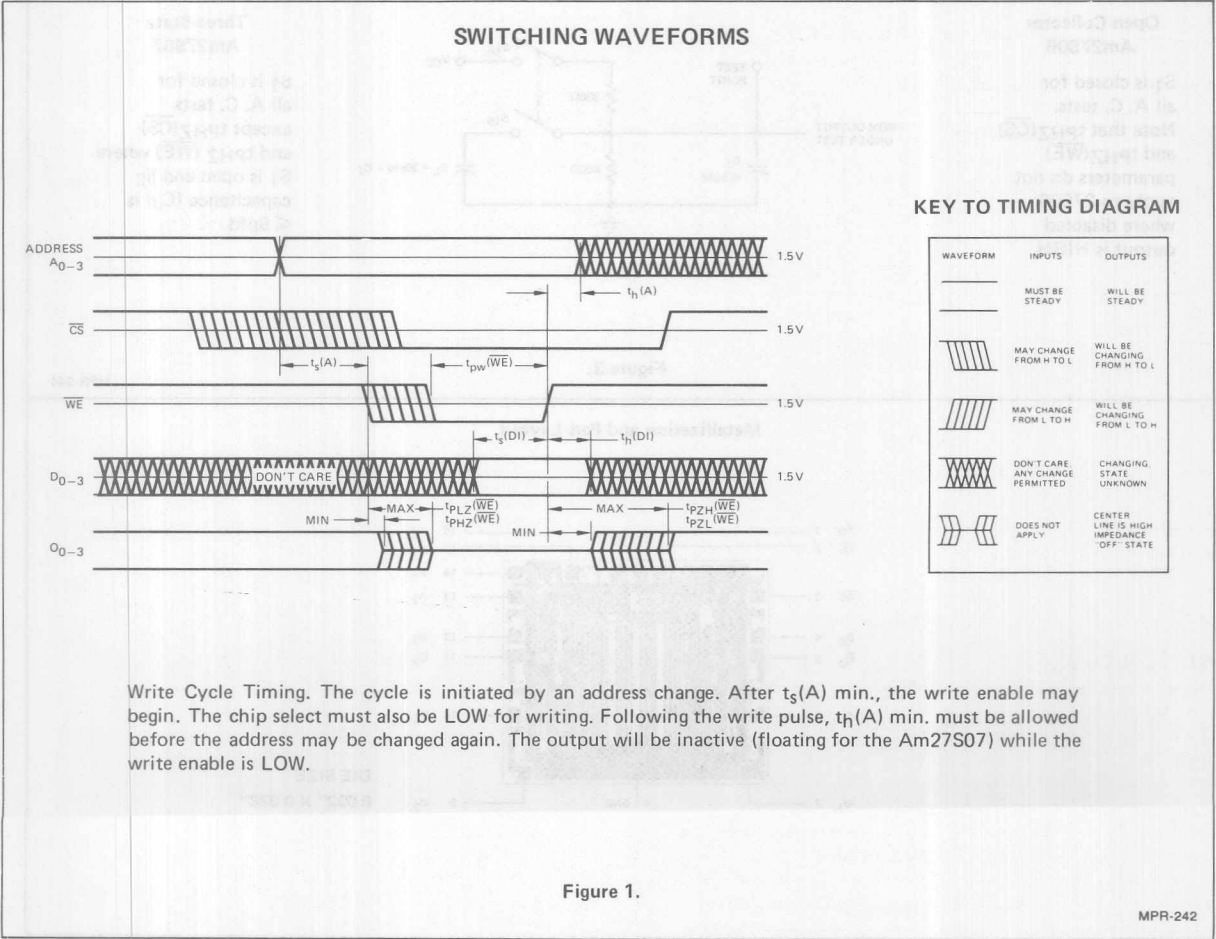
| Input |            | Function | Data Output Status<br>Q <sub>0</sub> -3 |
|-------|------------|----------|---|
| CE    | WE         |          |   |
| Low   | Low        | Write    | Output Disabled                         |
| Low   | High       | Read     | Selected Word                           |
| High  | Don't Care | Deselect | Output and Write Disabled               |



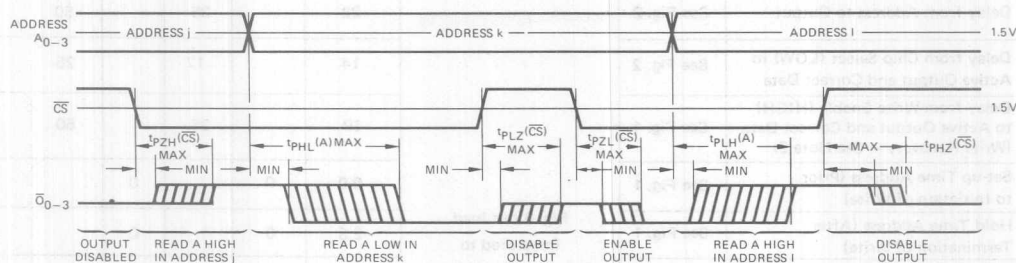
SWITCHING CHARACTERISTICS OVER OPERATING RANGE (Unless Otherwise Noted)

| Parameters            | Description  | A. C.<br>Test Conditions | Typ.<br>(Note 1) | COM'L |      | MIL  |      | Units |
|-----------------------|--|--------------------------|------------------|-------|------|------|------|-------|
|                       |  |                          |                  | Min.  | Max. | Min. | Max. |       |
| t <sub>PLH</sub> (A)  | Delay from Address to Output                                     | See Fig. 2               | 22               |       | 35   |      | 50   | ns    |
| t <sub>PHL</sub> (A)  |  |                          |                  |       |      |      |      |       |
| t <sub>PZH</sub> (CS) | Delay from Chip Select (LOW) to Active Output and Correct Data   | See Fig. 2               | 14               |       | 17   |      | 25   | ns    |
| t <sub>PZL</sub> (CS) |  |                          |                  |       |      |      |      |       |
| t <sub>PZH</sub> (WE) | Delay from Write Enable (HIGH) to Active Output and Correct Data | See Fig. 1               | 19               |       | 35   |      | 50   | ns    |
| t <sub>PZL</sub> (WE) | Write Recovery — See Note 2                                      |                          |                  |       |      |      |      |       |
| t <sub>s</sub> (A)    | Set-up Time Address (Prior to Initiation of Write)               | See Fig. 1               | -6.0             | 0     |      | 0    |      | ns    |
| t <sub>h</sub> (A)    | Hold Time Address (After Termination of Write)                   | See Fig. 1               | -2.5             | 0     |      | 0    |      | ns    |
| t <sub>s</sub> (DI)   | Set-up Time Data Input (Prior to Termination of Write)           | See Fig. 1               | 18               | 25    |      | 25   |      | ns    |
| t <sub>h</sub> (DI)   | Hold Time Data Input (After Termination of Write)                | See Fig. 1               | -4.0             | 0     |      | 0    |      | ns    |
| t <sub>pw</sub> (WE)  | Min. Write Enable Pulse Width to Insure Write                    | See Fig. 1               | 18               | 25    |      | 25   |      | ns    |
| t <sub>PHZ</sub> (CS) | Delay from Chip Select (HIGH) to Inactive Output (HI-Z)          | See Fig. 2               | 13               |       | 17   |      | 25   | ns    |
| t <sub>PLZ</sub> (CS) |  |                          |                  |       |      |      |      |       |
| t <sub>PLZ</sub> (WE) | Delay from Write Enable (LOW) to Inactive Output (HI-Z)          | See Fig. 1               | 15               |       | 25   |      | 35   | ns    |
| t <sub>PHZ</sub> (WE) |  |                          |                  |       |      |      |      |       |

Notes: 1. Typical limits are at V<sub>CC</sub> = 5.0V and T<sub>A</sub> = 25°C.  
2. Output is preconditioned to data in during write to insure correct data is present on all outputs when write is terminated. (No write recovery glitch)



## SWITCHING WAVEFORMS (Cont.)



Switching delays from address and chip select inputs to the data output. For the Am27S07 disabled output is "OFF", represented by a single center line. For the Am27S06, a disabled output is HIGH.

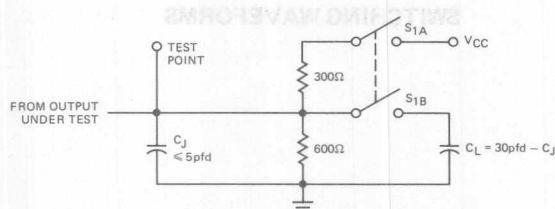
Figure 2.

MPR-243

## TEST LOAD

Open Collector  
Am27S06

S<sub>1</sub> is closed for all A. C. tests. Note that  $t_{PHZ}(\overline{CS})$  and  $t_{PHZ}(\overline{WE})$  parameters do not apply to 27S06 where disabled output is HIGH.

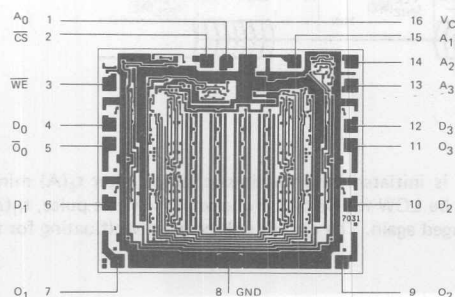
Three-State  
Am27S07

S<sub>1</sub> is closed for all A. C. tests except  $t_{PHZ}(\overline{CS})$  and  $t_{PHZ}(\overline{WE})$  where S<sub>1</sub> is open and jig capacitance (C<sub>j</sub>) is ≤ 5pfd.

Figure 3.

MPR-244

## Metallization and Pad Layout



DIE SIZE

0.092'' X 0.078''

# Am27S12 • Am27S13

2048-Bit Generic Series Bipolar PROM

## DISTINCTIVE CHARACTERISTICS

- High Speed – 50ns max commercial range access time
- Excellent performance over full MIL and commercial ranges
- Highly reliable, ultra-fast programming Platinum-Silicide fuses
- High programming yield
- Low current PNP inputs
- High current open collector and three-state outputs
- Fast chip select
- Access time tested with N<sup>2</sup> patterns
- Pin for pin replacements for industry standard products
- Common Generic PROM series electrical characteristics and simple programming procedures.

## GENERIC SERIES CHARACTERISTICS

The Am27S12 and Am27S13 are members of an Advanced PROM series incorporating common electrical characteristics and programming procedures. All parts in this series are produced with a fusible link at each memory location storing a logic LOW and can be selectively programmed to a logic HIGH by applying appropriate voltages to the circuit.

All parts are fabricated with AMD's fast programming highly reliable Platinum-Silicide Fuse technology. Utilizing easily implemented programming (and common programming personality card sets) these products can be rapidly programmed to any customized pattern. Extra test words are pre-programmed during manufacturing to insure extremely high field programming yields, and produce excellent parametric correlation.

Platinum-Silicide was selected as the fuse link material to achieve a well controlled melt rate resulting in large non-conductive gaps that ensure very stable long term reliability. Extensive operating testing has proven that this low-field, large-gap technology offers the best reliability for fusible link PROMs.

Common design features include active loading of all critical AC paths regulated by a built-in temperature and voltage compensated bias network to provide excellent parametric performance over MIL supply and temperature ranges. Selective feedback techniques have been employed to minimize delays through all critical paths producing the fastest speeds possible from Schottky processed PROMs.

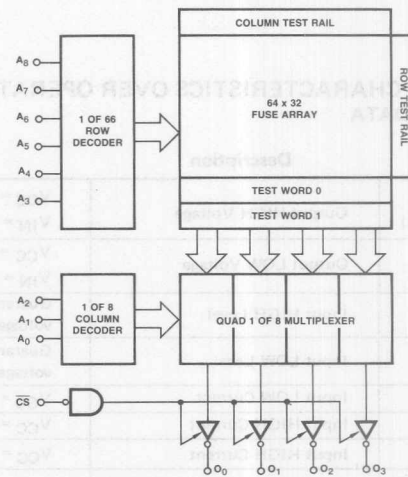
## ORDERING INFORMATION

| Package Type        | Temperature Range | Order Number |
|---------------------|-------------------|--------------|
| Open Collectors     |                   |              |
| Hermetic DIP        | 0°C to +75°C      | AM27S12DC    |
| Hermetic DIP        | -55°C to +125°C   | AM27S12DM    |
| Hermetic Flat Pak   | -55°C to +125°C   | AM27S12FM    |
| Three-State Outputs |                   |              |
| Hermetic DIP        | 0°C to +75°C      | AM27S13DC    |
| Hermetic DIP        | -55°C to +125°C   | AM27S13DM    |
| Hermetic Flat Pak   | -55°C to +125°C   | AM27S13FM    |

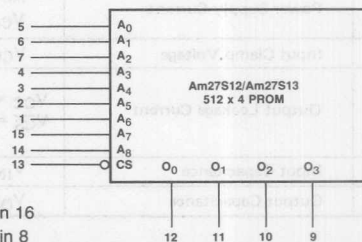
## FUNCTIONAL DESCRIPTION

The Am27S12 and Am27S13 are high speed electrically programmable Schottky read only memories. Organized in the industry standard 512 x 4 configuration, they are available in both open collector Am27S12 and three-state Am27S13 output versions. After programming, stored information is read on outputs O<sub>0</sub>–O<sub>3</sub> by applying unique binary addresses to A<sub>0</sub>–A<sub>8</sub> and holding the chip select input, CS, at a logic LOW. If the chip select input goes to a logic HIGH, O<sub>0</sub>–O<sub>3</sub> go to the off or high impedance state.

## BLOCK DIAGRAM

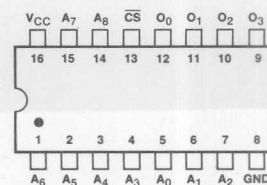


## LOGIC SYMBOL



V<sub>CC</sub> = Pin 16  
GND = Pin 8

## CONNECTION DIAGRAM Top View



Note: Pin 1 is marked for orientation.

## Am27S12 • Am27S13

### MAXIMUM RATINGS (Above which the useful life may be impaired)

|  |                                |
|--|--------------------------------|
| Storage Temperature  | -65°C to +150°C                |
| Temperature (Ambient) Under Bias   | -55°C to +125°C                |
| Supply Voltage to Ground Potential (Pin 16 to Pin 8) Continuous          | -0.5V to +7.0V                 |
| DC Voltage Applied to Outputs (Except During Programming)                | -0.5V to +V <sub>CC</sub> max. |
| DC Voltage Applied to Outputs During Programming                         | 21V                            |
| Output Current into Outputs During Programming (Max. Duration of 1 sec.) | 200mA                          |
| DC Input Voltage   | -0.5V to +5.5V                 |
| DC Input Current   | -30mA to +5mA                  |

### OPERATING RANGE

|       |                      |                                  |                             |
|-------|----------------------|----------------------------------|-----------------------------|
| COM'L | Am27S12XC, Am27S13XC | T <sub>A</sub> = 0°C to +75°C    | V <sub>CC</sub> = 5.0V ±5%  |
| MIL   | Am27S12XM, Am27S13XM | T <sub>A</sub> = -55°C to +125°C | V <sub>CC</sub> = 5.0V ±10% |

### ELECTRICAL CHARACTERISTICS OVER OPERATING RANGE (Unless Otherwise Noted) PRELIMINARY DATA

| Parameters                        | Description                  | Test Conditions  | Min. | Typ.<br>(Note 1) | Max.   | Units |
|-----------------------------------|------------------------------|--|------|------------------|--------|-------|
| V <sub>OH</sub><br>(Am27S13 only) | Output HIGH Voltage          | V <sub>CC</sub> = MIN., I <sub>OH</sub> = -2.0mA<br>V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub> | 2.4  |                  |        | Volts |
| V <sub>OL</sub>                   | Output LOW Voltage           | V <sub>CC</sub> = MIN., I <sub>OL</sub> = 16mA<br>V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>   |      |                  | 0.45   | Volts |
| V <sub>IH</sub>                   | Input HIGH Level             | Guaranteed input logical HIGH voltage for all inputs   | 2.0  |                  |        | Volts |
| V <sub>IL</sub>                   | Input LOW Level              | Guaranteed input logical LOW voltage for all inputs  |      |                  | 0.8    | Volts |
| I <sub>IL</sub>                   | Input LOW Current            | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 0.45V  |      | -0.010           | -0.250 | mA    |
| I <sub>IH</sub>                   | Input HIGH Current           | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 2.7V   |      |                  | 25     | μA    |
| I <sub>I</sub>                    | Input HIGH Current           | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 5.5V   |      |                  | 1.0    | mA    |
| I <sub>SC</sub><br>(Am27S13 only) | Output Short Circuit Current | V <sub>CC</sub> = MAX., V <sub>OUT</sub> = 0.0V (Note 2)   | -20  | -40              | -90    | mA    |
| I <sub>CC</sub>                   | Power Supply Current         | All inputs = GND<br>V <sub>CC</sub> = MAX.   |      | 100              | 130    | mA    |
| V <sub>I</sub>                    | Input Clamp Voltage          | V <sub>CC</sub> = MIN., I <sub>IN</sub> = -18mA  |      |                  | -1.2   | Volts |
| I <sub>CEX</sub>                  | Output Leakage Current       | V <sub>CC</sub> = MAX.<br>V <sub>CS</sub> = 2.4V   |      |                  | 40     | μA    |
|                                   |                              | Am27S13 only   |      |                  | 40     |       |
|                                   |                              |  |      |                  | -40    |       |
| C <sub>IN</sub>                   | Input Capacitance            | V <sub>IN</sub> = 2.0V @ f = 1 MHz (Note 3)  |      | 4                |        | pF    |
| C <sub>OUT</sub>                  | Output Capacitance           | V <sub>OUT</sub> = 2.0V @ f = 1 MHz (Note 3)   |      | 8                |        |       |

Notes: 1. Typical limits are at V<sub>CC</sub> = 5.0V and T<sub>A</sub> = 25°C.

2. Not more than one output should be shorted at a time. Duration of the short circuit should not be more than one second.

3. These parameters are not 100% tested, but are periodically sampled.

# SWITCHING CHARACTERISTICS OVER OPERATING RANGE

## PRELIMINARY DATA

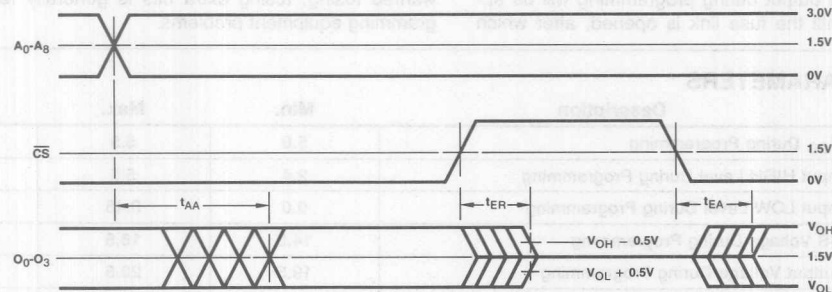
| Parameter | Description          | Test Conditions                 | Typ        | Max   |     | Units |
|-----------|----------------------|---------------------------------|------------|-------|-----|-------|
|           |                      |                                 | 5V<br>25°C | COM'L | MIL |       |
| $t_{AA}$  | Address Access Time  | AC Test Load<br>(See Notes 1-3) | 30         | 50    | 60  | ns    |
| $t_{EA}$  | Enable Access Time   |                                 | 15         | 25    | 30  | ns    |
| $t_{ER}$  | Enable Recovery Time |                                 | 15         | 25    | 30  | ns    |

Notes: 1.  $t_{AA}$  is tested with switch  $S_1$  closed and  $C_L = 30\text{pF}$ .

2. For open collector outputs,  $t_{EA}$  and  $t_{ER}$  are tested with  $S_1$  closed to the 1.5V output level.  $C_L = 30\text{pF}$ .

3. For three state outputs,  $t_{EA}$  is tested with  $C_L = 30\text{pF}$  to the 1.5V level;  $S_1$  is open for high impedance to HIGH tests and closed for high impedance to LOW tests.  $t_{ER}$  is tested with  $C_L = 5\text{pF}$ . HIGH to high impedance tests are made with  $S_1$  open to an output voltage of  $V_{OH} - 0.5\text{V}$ ; LOW to high impedance tests are made with  $S_1$  closed to the  $V_{OL} + 0.5\text{V}$  level.

## SWITCHING WAVEFORMS



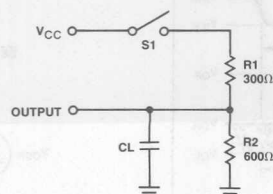
Note: Level on output while  $\overline{CS}$  is HIGH is determined externally.

BPM-004

## KEY TO TIMING DIAGRAM

| WAVEFORM | INPUTS                 | OUTPUTS                      | WAVEFORM | INPUTS                           | OUTPUTS                                   |
|----------|------------------------|------------------------------|----------|----------------------------------|---|
|          | MUST BE STEADY         | WILL BE STEADY               |          | DON'T CARE; ANY CHANGE PERMITTED | CHANGING; STATE UNKNOWN                   |
|          | MAY CHANGE FROM H TO L | WILL BE CHANGING FROM H TO L |          | DOES NOT APPLY                   | CENTER LINE IS HIGH IMPEDANCE "OFF" STATE |
|          | MAY CHANGE FROM L TO H | WILL BE CHANGING FROM L TO H |          |                                  |   |

## AC TEST LOAD



BPM-005



## PROGRAMMING

The Am27S12 and Am27S13 are manufactured with a conductive Platinum-Silicide link at each bit location. The output of the memory with the link in place is LOW. To program the device, the fusible links are selectively opened.

The fusible links are opened one at a time by passing current through them from a 20 volt supply which is applied to one memory output after the  $\overline{CS}$  input is at a logic HIGH. Current is gated through the addressed fuse by raising the  $\overline{CS}$  input from a logic HIGH to 15 volts. After 50  $\mu\text{sec}$ , the 20 volt supply is removed, the chip enabled, and the output level sensed to determine if the link has opened. Most links will open within 50  $\mu\text{sec}$ . Occasionally a link will be stronger and require additional programming cycle. The recommended duration of additional programming periods is 5 msec. If a link has not opened after a total elapsed programming time of 400 msec, further programming of the device should not be attempted. Successive links are programmed in the same manner until all desired bit locations have been programmed to the HIGH level.

Typical current into an output during programming will be approximately 140mA until the fuse link is opened, after which

the current drops to approximately 40mA. Current into the  $\overline{CS}$  pin when it is raised to 15 volts is typically 1.5mA.

The memories may become hot during programming due to the large currents being passed. Programming cycles should not be applied to one device more than 5 seconds to avoid heat damage. If this programming time is exceeded, all power to the chip including  $V_{CC}$  should be removed for a period of 5 seconds after which programming may be resumed.

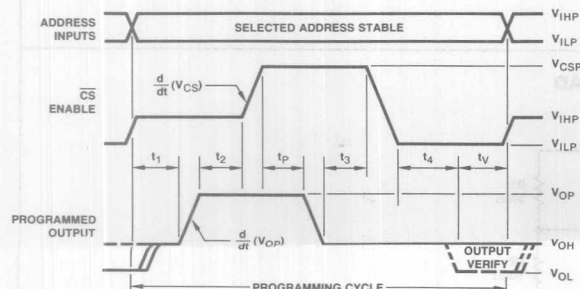
When all programming has been completed, the data content of the memory should be verified by sequentially reading all words. Occasionally this verification will show that an extra undesired link has been fused. Should this occur, immediately check the programming equipment to make sure that all device pins are firmly contacting the programming socket, that the input signal levels exhibit sufficient noise margins, and that the programming voltages are within the specified limits. All of these conditions must be maintained during programming. AMD PROMs are thoroughly tested to minimize unwanted fusing; fusing extra bits is generally related to programming equipment problems.

## PROGRAMMING PARAMETERS

| Parameter      | Description                                | Min. | Max.            | Units              |
|----------------|--|------|-----------------|--------------------|
| $V_{CCP}$      | $V_{CC}$ During Programming                | 5.0  | 5.5             | Volts              |
| $V_{IHP}$      | Input HIGH Level During Programming        | 2.4  | 5.5             | Volts              |
| $V_{ILP}$      | Input LOW Level During Programming         | 0.0  | 0.45            | Volts              |
| $V_{CSP}$      | $\overline{CS}$ Voltage During Programming | 14.5 | 15.5            | Volts              |
| $V_{OP}$       | Output Voltage During Programming          | 19.5 | 20.5            | Volts              |
| $V_{ONP}$      | Voltage on Outputs Not to be Programmed    | 0    | $V_{CCP} + 0.3$ | Volts              |
| $I_{ONP}$      | Current into Outputs Not to be Programmed  |      | 20              | mA                 |
| $d(V_{OP})/dt$ | Rate of Output Voltage Change              | 20   | 250             | V/ $\mu\text{sec}$ |
| $d(V_{CS})/dt$ | Rate of $\overline{CS}$ Voltage Change     | 100  | 1000            | V/ $\mu\text{sec}$ |
| $t_p$          | Programming Period – First Attempt         | 50   | 100             | $\mu\text{sec}$    |
|                | Programming Period – Subsequent Attempts   | 5.0  | 15              | msec               |

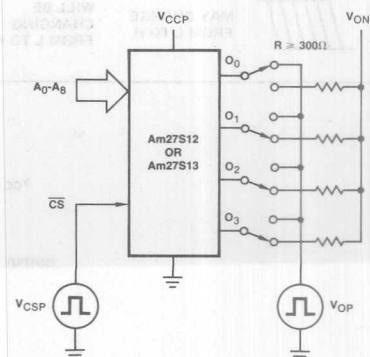
- Notes: 1. All delays between edges are specified from completion of the first edge to beginning of the second edge; i.e., not to the midpoints.  
 2. Delays  $t_1$ ,  $t_2$ ,  $t_3$  and  $t_4$  must be greater than 100 ns; maximum delays of 1  $\mu\text{sec}$  are recommended to minimize heating during programming.  
 3. During  $t_v$ , a user defined period, the output being programmed is switched to the load R and read to determine if additional pulses are required.  
 4. Outputs not being programmed are connected to  $V_{ONP}$  through resistor R which provides output current limiting.

## PROGRAMMING WAVEFORMS



BPM-006

## SIMPLIFIED PROGRAMMING DIAGRAM



BPM-007

## PROGRAMMING EQUIPMENT

Generic programming boards and device adapters are available from the sources listed below. In each case, the programming boards are used in these manufacturer's automatic

programmers to program all AMD generic series bipolar PROMs; individual adapters are required for each basic part type in the series.

|   |  |  |
|---|--|--|
| SOURCE AND LOCATION                               | Data I/O Corp<br>P.O. Box 308<br>Issaquah, Wash. 98027 | Pro-Log Corp.<br>2411 Garden Road<br>Monterey, Ca. 93940 |
| PROGRAMMER MODEL(S)                               | Model 5, 7 and 9                                       | M900 and M920  |
| AMD GENERIC BIPOLAR<br>PROM PERSONALITY BOARD     | 909-1286-1   | PM9058   |
| Am27S12 • Am27S13<br>ADAPTERS AND<br>CONFIGURATOR | 715-1408-2   | PA16-5 and 512 x 4 (L)                                   |

## OBTAINING PROGRAMMED UNITS

Programmed devices may be purchased from your distributor or Advanced Micro Devices. The program data should be submitted in the form of a punched paper tape and must be accompanied by a written truth table. The punched tape can be delivered with your order or may be transmitted over a TWX machine or time-sharing terminal. ASCII BPNF is our preferred paper tape format.

Truth tables are also acceptable, but are much less desirable especially for larger density PROMs. Submission of a truth table requires the generation of a punched paper tape at the distributor or factory resulting in longer lead times, greater possibility of error, and higher cost.

## ASCII BPNF

An example of an ASCII tape in the BPNF format is shown below. They can be punched on any Teletype® or on a TWX or Telex machine. The format chosen provides relatively good error detection. Paper tapes must consist of:

1. A leader of at least 25 rubouts.
2. The data patterns for all 512 words, starting with word 0, in the following format:
  - a. Any characters, including carriage return and line feed, except "B".
  - b. The letter "B", indicating the beginning of the data word.
  - c. A sequence of four Ps or Ns, starting with output O<sub>3</sub>.
  - d. The letter "F", indicating the finish of the data word.
  - e. Any text, including carriage return and line feed, except the letter "B".

3. A trailer of at least 25 rubouts.

A P is a HIGH logic level = 2.4 volts.

An N is a LOW logic level = 0.4 volts.

A convenient pattern to use for the data words is to prefix the word (or every few words with the word number, then type the data word, then a comment, then carriage return and line feed as shown below. There must be no characters between the B and the F except for the four Ps and Ns. If an error is made in a word, the entire word must be cancelled with rubouts back to the letter B, then the word re-typed beginning with the B.

When TWXing your tape, be sure the tape is in even parity. Parity is not necessary if the tape is mailed.

## TYPICAL PAPER TAPE FORMAT

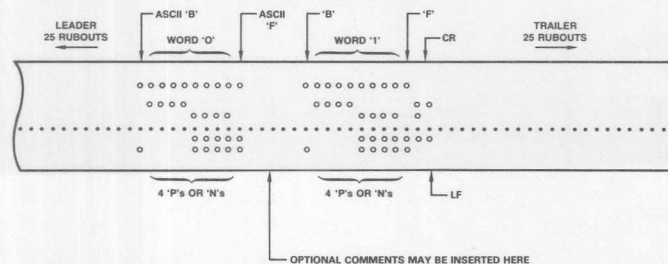
```

000 BNNNPF WORD ZERO (R) (L)
001 BPPNPF COMMENT FIELD (R) (L)
002 BPPNPF ANY (R) (L)
003 BNNNPF TEXT (R) (L)
004 BNNNPF CAN (R) (L)
005 BPPNPF GO (R) (L)
006 BPPNPF HERE (R) (L)
...
511 BPPNPF END (R) (L)
  
```

## RESULTING DEVICE TRUTH TABLE ( $\overline{CS}$ = LOW)

| A <sub>8</sub> | A <sub>7</sub> | A <sub>6</sub> | A <sub>5</sub> | A <sub>4</sub> | A <sub>3</sub> | A <sub>2</sub> | A <sub>1</sub> | A <sub>0</sub> | O <sub>3</sub> | O <sub>2</sub> | O <sub>1</sub> | O <sub>0</sub> |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| L              | L              | L              | L              | L              | L              | L              | L              | L              | L              | L              | L              | H              |
| L              | L              | L              | L              | L              | L              | L              | L              | H              | H              | H              | L              | L              |
| L              | L              | L              | L              | L              | L              | L              | H              | L              | H              | H              | L              | L              |
| L              | L              | L              | L              | L              | L              | L              | H              | H              | L              | L              | L              | L              |
| L              | L              | L              | L              | L              | L              | H              | L              | L              | L              | L              | L              | H              |
| L              | L              | L              | L              | L              | L              | H              | L              | H              | H              | H              | L              | L              |
| L              | L              | L              | L              | L              | L              | H              | H              | L              | H              | H              | L              | L              |
|                |                |                |                |                |                |                |                |                |                |                |                |                |
| H              | H              | H              | H              | H              | H              | H              | H              | H              | H              | H              | H              | L              |

## ASCII PAPER TAPE

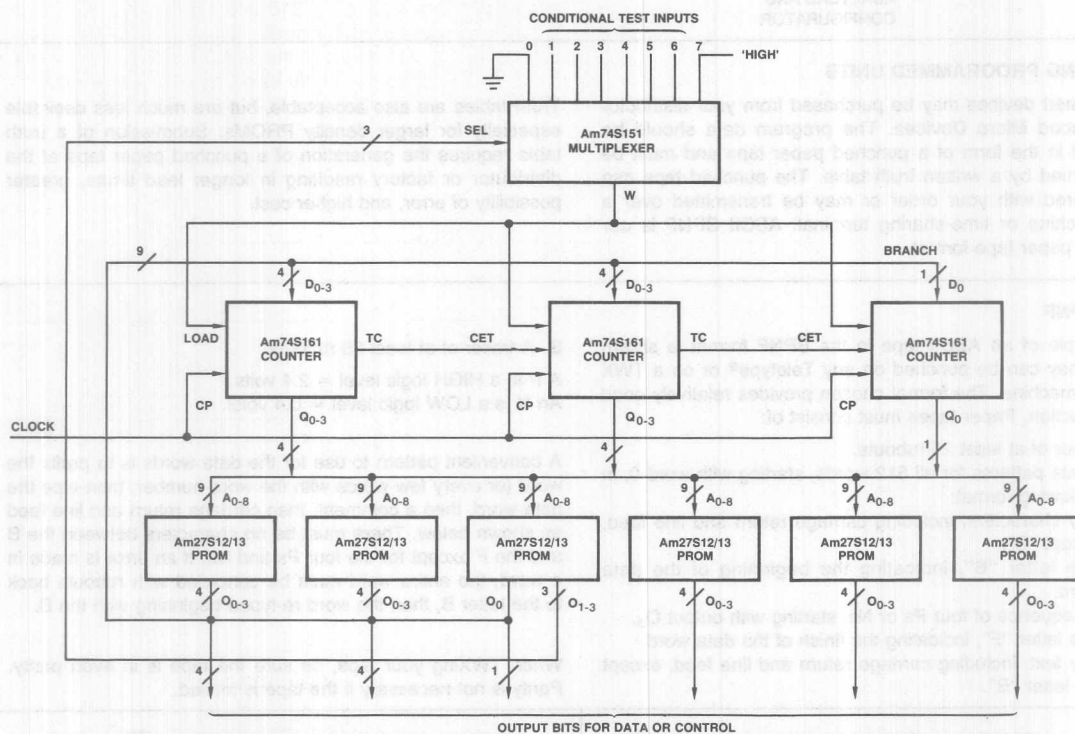


BPM-008

## APPLYING THE Am27S12 AND Am27S13

The Am27S12 and Am27S13 can be used with a high speed counter to form a pico-controller for microprogrammed systems. A typical application is illustrated below wherein a multiplexer, under control of one of the PROMs, is continuously sensing the **CONDITIONAL TEST INPUTS**. When the selected condition occurs, a **HIGH** signal will result at the mul-

plexer output causing a predetermined branch address to be loaded into the parallel inputs of the counters on the next clock pulse. The counter then accesses the preprogrammed data or control information sequence from the Am27S12 or Am27S13 PROMs.



BPM-009

# Am27S18 • Am27S19

256-Bit Generic Series Bipolar PROM

## DISTINCTIVE CHARACTERISTICS

- High Speed — 40ns max commercial range access time
- Excellent performance over full MIL and commercial ranges
- Highly reliable, ultra-fast programming Platinum-Silicide fuses
- High programming yield
- Low current PNP inputs
- High current open collector and three-state outputs
- Fast chip select
- Access time tested with  $N^2$  patterns
- Pin for pin replacements for industry standard products
- Common Generic PROM series electrical characteristics and simple programming procedures.

## GENERIC SERIES CHARACTERISTICS

The Am27S18 and Am27S19 are members of an Advanced PROM series incorporating common electrical characteristics and programming procedures. All parts in this series are produced with a fusible link at each memory location storing a logic LOW and can be selectively programmed to a logic HIGH by applying appropriate voltages to the circuit.

All parts are fabricated with AMD's fast programming highly reliable Platinum-Silicide Fuse technology. Utilizing easily implemented programming (and common programming personal-ity card sets) these products can be rapidly programmed to any customized pattern. Extra test words are pre-programmed during manufacturing to insure extremely high field program-ing yields, and produce excellent parametric correlation.

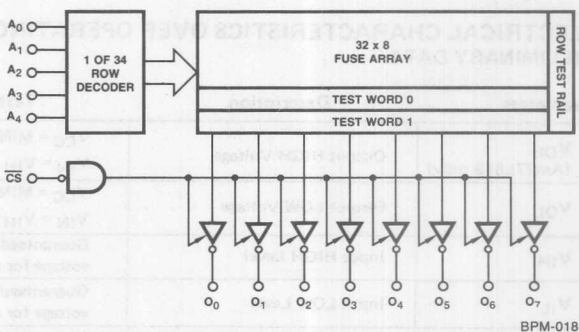
Platinum-Silicide was selected as the fuse link material to achieve a well controlled melt rate resulting in large non-conductive gaps that ensure very stable long term reliability. Extensive operating testing has proven that this low-field, large-gap technology offers the best reliability for fusible link PROMs.

Common design features include active loading of all critical AC paths regulated by a built-in temperature and voltage compensated bias network to provide excellent parametric performance over MIL supply and temperature ranges. Selective feedback techniques have been employed to minimize de-lays through all critical paths producing the fastest speeds possible from Schottky processed PROMs.

## FUNCTIONAL DESCRIPTION

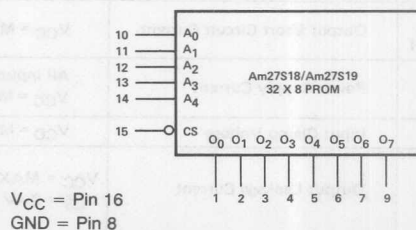
The Am27S18 and Am27S19 are high speed electrically pro-grammable Schottky read only memories. Organized in the industry standard  $32 \times 8$  configuration, they are available in both open collector Am27S18 and three-state Am27S19 out-put versions. After programming, stored information is read on outputs  $O_0$ – $O_7$  by applying unique binary addresses to  $A_0$ – $A_4$  and holding the chip select input,  $\overline{CS}$ , at a logic LOW. If the chip select input goes to a logic HIGH,  $O_0$ – $O_7$  go to the off or high impedance state.

## BLOCK DIAGRAM



BPM-018

## LOGIC SYMBOL

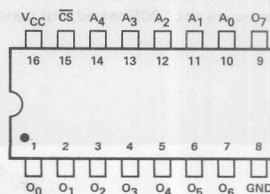


BPM-019

## ORDERING INFORMATION

| Package Type        | Temperature Range | Order Number |
|---------------------|-------------------|--------------|
| Open Collectors     |                   |              |
| Hermetic DIP        | 0°C to +75°C      | AM27S18DC    |
| Hermetic DIP        | –55°C to +125°C   | AM27S18DM    |
| Hermetic Flat Pak   | –55°C to +125°C   | AM27S18FM    |
| Three-State Outputs |                   |              |
| Hermetic DIP        | 0°C to +75°C      | AM27S19DC    |
| Hermetic DIP        | –55°C to +125°C   | AM27S19DM    |
| Hermetic Flat Pak   | –55°C to +125°C   | AM27S19FM    |

## CONNECTION DIAGRAM Top View



Note: Pin 1 is marked for orientation.

BPM-020



# Am27S18 • Am27S19

## MAXIMUM RATINGS (Above which the useful life may be impaired)

|  |                                |
|--|--------------------------------|
| Storage Temperature  | -65°C to +150°C                |
| Temperature (Ambient) Under Bias   | -55°C to +125°C                |
| Supply Voltage to Ground Potential (Pin 16 to Pin 8) Continuous          | -0.5V to +7.0V                 |
| DC Voltage Applied to Outputs (Except During Programming)                | -0.5V to +V <sub>CC</sub> max. |
| DC Voltage Applied to Outputs During Programming                         | 21V                            |
| Output Current into Outputs During Programming (Max. Duration of 1 sec.) | 200mA                          |
| DC Input Voltage   | -0.5V to +5.5V                 |
| DC Input Current   | -30mA to +5mA                  |

## OPERATING RANGE

|       |                      |                                  |                             |
|-------|----------------------|----------------------------------|-----------------------------|
| COM'L | Am27S18XC, Am27S19XC | T <sub>A</sub> = 0°C to +75°C    | V <sub>CC</sub> = 5.0V ±5%  |
| MIL   | Am27S18XM, Am27S19XM | T <sub>A</sub> = -55°C to +125°C | V <sub>CC</sub> = 5.0V ±10% |

## ELECTRICAL CHARACTERISTICS OVER OPERATING RANGE (Unless Otherwise Noted) PRELIMINARY DATA

| Parameters                         | Description                  | Test Conditions  | Min. | Typ.<br>(Note 1) | Max.   | Units |
|------------------------------------|------------------------------|--|------|------------------|--------|-------|
| V <sub>OH</sub><br>(Am27LS19 only) | Output HIGH Voltage          | V <sub>CC</sub> = MIN., I <sub>OH</sub> = -2.0mA<br>V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub> | 2.4  |                  |        | Volts |
| V <sub>OL</sub>                    | Output LOW Voltage           | V <sub>CC</sub> = MIN., I <sub>OL</sub> = 16mA<br>V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>   |      |                  | 0.45   | Volts |
| V <sub>IH</sub>                    | Input HIGH Level             | Guaranteed input logical HIGH voltage for all inputs   | 2.0  |                  |        | Volts |
| V <sub>IL</sub>                    | Input LOW Level              | Guaranteed input logical LOW voltage for all inputs  |      |                  | 0.8    | Volts |
| I <sub>IL</sub>                    | Input LOW Current            | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 0.45V  |      | -0.010           | -0.250 | mA    |
| I <sub>IH</sub>                    | Input HIGH Current           | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 2.7V   |      |                  | 25     | μA    |
| I <sub>I</sub>                     | Input HIGH Current           | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 5.5V   |      |                  | 1.0    | mA    |
| I <sub>SC</sub><br>(Am27LS19 only) | Output Short Circuit Current | V <sub>CC</sub> = MAX., V <sub>OUT</sub> = 0.0V (Note 2)   | -20  | -40              | -90    | mA    |
| I <sub>CC</sub>                    | Power Supply Current         | All inputs = GND<br>V <sub>CC</sub> = MAX.   |      | 90               | 115    | mA    |
| V <sub>I</sub>                     | Input Clamp Voltage          | V <sub>CC</sub> = MIN., I <sub>IN</sub> = -18mA  |      |                  | -1.2   | Volts |
| I <sub>CEX</sub>                   | Output Leakage Current       | V <sub>CC</sub> = MAX.<br>V <sub>CS</sub> = 2.4V   |      |                  | 40     | μA    |
|                                    |                              | Am27LS19 only  |      |                  | 40     |       |
|                                    |                              |  |      |                  | -40    |       |
| C <sub>IN</sub>                    | Input Capacitance            | V <sub>IN</sub> = 2.0V @ f = 1 MHz (Note 3)  |      | 4                |        | pF    |
| C <sub>OUT</sub>                   | Output Capacitance           | V <sub>OUT</sub> = 2.0V @ f = 1 MHz (Note 3)   |      | 8                |        |       |

Notes: 1. Typical limits are at V<sub>CC</sub> = 5.0V and T<sub>A</sub> = 25°C.

2. Not more than one output should be shorted at a time. Duration of the short circuit should not be more than one second.

3. These parameters are not 100% tested, but periodically sampled.



# SWITCHING CHARACTERISTICS OVER OPERATING RANGE

## PRELIMINARY DATA

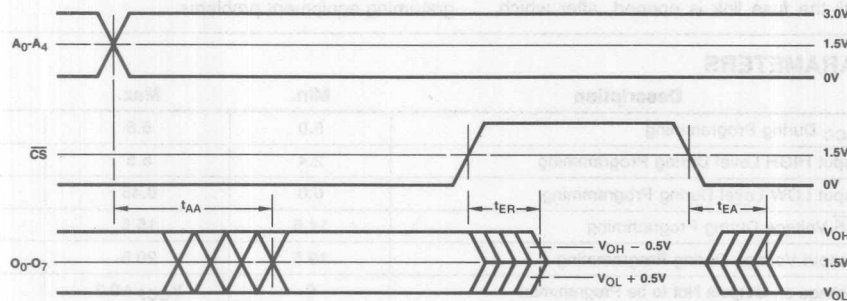
| Parameter       | Description          | Test Conditions                 | Typ        | Max   |     | Units |
|-----------------|----------------------|---------------------------------|------------|-------|-----|-------|
|                 |                      |                                 | 5V<br>25°C | COM'L | MIL |       |
| t <sub>AA</sub> | Address Access Time  | AC Test Load<br>(See Notes 1-3) | 25         | 40    | 50  | ns    |
| t <sub>EA</sub> | Enable Access Time   |                                 | 15         | 25    | 30  | ns    |
| t <sub>ER</sub> | Enable Recovery Time |                                 | 15         | 25    | 30  | ns    |

Notes: 1.  $t_{AA}$  is tested with switch  $S_1$  closed and  $C_L = 30\text{pF}$ .

2. For open collector outputs,  $t_{EA}$  and  $t_{ER}$  are tested with  $S_1$  closed to the 1.5V output level.  $C_L = 30\text{pF}$ .

3. For three state outputs,  $t_{EA}$  is tested with  $C_L = 30\text{pF}$  to the 1.5V level;  $S_1$  is open for high impedance to HIGH tests and closed for high impedance to LOW tests.  $t_{ER}$  is tested with  $C_L = 5\text{pF}$ . HIGH to high impedance tests are made with  $S_1$  open to an output voltage of  $V_{OH} - 0.5\text{V}$ ; LOW to high impedance tests are made with  $S_1$  closed to the  $V_{OL} + 0.5\text{V}$  level.

## SWITCHING WAVEFORMS



Note: Level on output while  $\overline{CS}$  is HIGH is determined externally.

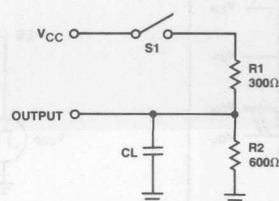
BPM-021

5

## KEY TO TIMING DIAGRAM

| WAVEFORM | INPUTS                 | OUTPUTS                      | WAVEFORM | INPUTS                           | OUTPUTS                                   |
|----------|------------------------|------------------------------|----------|----------------------------------|---|
|          | MUST BE STEADY         | WILL BE STEADY               |          | DON'T CARE; ANY CHANGE PERMITTED | CHANGING; STATE UNKNOWN                   |
|          | MAY CHANGE FROM H TO L | WILL BE CHANGING FROM H TO L |          | DOES NOT APPLY                   | CENTER LINE IS HIGH IMPEDANCE "OFF" STATE |
|          | MAY CHANGE FROM L TO H | WILL BE CHANGING FROM L TO H |          |                                  |   |

## AC TEST LOAD



BPM-022

## PROGRAMMING

The Am27S18 and Am27S19 are manufactured with a conductive Platinum-Silicide link at each bit location. The output of the memory with the link in place is LOW. To program the device, the fusible links are selectively opened.

The fusible links are opened one at a time by passing current through them from a 20 volt supply which is applied to one memory output after the  $\overline{CS}$  input is at a logic HIGH. Current is gated through the addressed fuse by raising the  $\overline{CS}$  input from a logic HIGH to 15 volts. After 50  $\mu\text{sec}$ , the 20 volt supply is removed, the chip enabled, and the output level sensed to determine if the link has opened. Most links will open within 50  $\mu\text{sec}$ . Occasionally a link will be stronger and require additional programming cycles. The recommended duration of additional programming periods is 5 msec. If a link has not opened after a total elapsed programming time of 400 msec, further programming of the device should not be attempted. Successive links are programmed in the same manner until all desired bit locations have been programmed to the HIGH level.

Typical current into an output during programming will be approximately 140mA until the fuse link is opened, after which

the current drops to approximately 40mA. Current into the  $\overline{CS}$  pin when it is raised to 15 volts is typically 1.5mA.

The memories may become hot during programming due to the large currents being passed. Programming cycles should not be applied to one device more than 5 seconds to avoid heat damage. If this programming time is exceeded, all power to the chip including  $V_{CC}$  should be removed for a period of 5 seconds after which programming may be resumed.

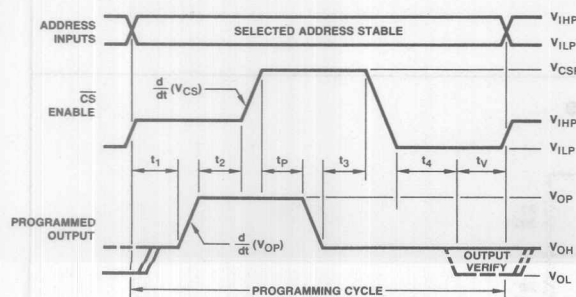
When all programming has been completed, the data content of the memory should be verified by sequentially reading all words. Occasionally this verification will show that an extra undesired link has been fused. Should this occur, immediately check the programming equipment to make sure that all device pins are firmly contacting the programming socket, that the input signal levels exhibit sufficient noise margins, and that the programming voltages are within the specified limits. All of these conditions must be maintained during programming. AMD PROMs are thoroughly tested to minimize unwanted fusing; fusing extra bits is generally related to programming equipment problems.

## PROGRAMMING PARAMETERS

| Parameter      | Description                                | Min. | Max.            | Units              |
|----------------|--|------|-----------------|--------------------|
| $V_{CCP}$      | $V_{CC}$ During Programming                | 5.0  | 5.5             | Volts              |
| $V_{IHP}$      | Input HIGH Level During Programming        | 2.4  | 5.5             | Volts              |
| $V_{ILP}$      | Input LOW Level During Programming         | 0.0  | 0.45            | Volts              |
| $V_{CSP}$      | $\overline{CS}$ Voltage During Programming | 14.5 | 15.5            | Volts              |
| $V_{OP}$       | Output Voltage During Programming          | 19.5 | 20.5            | Volts              |
| $V_{ONP}$      | Voltage on Outputs Not to be Programmed    | 0    | $V_{CCP} + 0.3$ | Volts              |
| $I_{ONP}$      | Current into Outputs Not to be Programmed  |      | 20              | mA                 |
| $d(V_{OP})/dt$ | Rate of Output Voltage Change              | 20   | 250             | V/ $\mu\text{sec}$ |
| $d(V_{CS})/dt$ | Rate of $\overline{CS}$ Voltage Change     | 100  | 1000            | V/ $\mu\text{sec}$ |
| $t_P$          | Programming Period – First Attempt         | 50   | 100             | $\mu\text{sec}$    |
|                | Programming Period – Subsequent Attempts   | 5.0  | 15              | msec               |

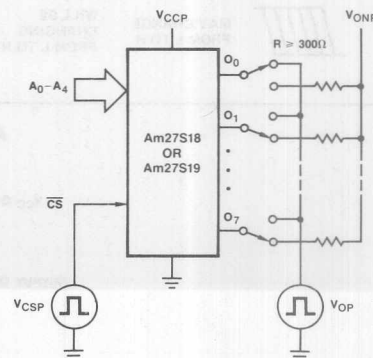
- Notes: 1. All delays between edges are specified from completion of the first edge to beginning of the second edge; i.e., not to the midpoints.  
 2. Delays  $t_1$ ,  $t_2$ ,  $t_3$  and  $t_4$  must be greater than 100 ns; maximum delays of 1  $\mu\text{sec}$  are recommended to minimize heating during programming.  
 3. During  $t_v$ , a user defined period, the output being programmed is switched to the load R and read to determine if additional pulses are required.  
 4. Outputs not being programmed are connected to  $V_{ONP}$  through resistor R which provides output current limiting.

## PROGRAMMING WAVEFORMS



BPM-023

## SIMPLIFIED PROGRAMMING DIAGRAM



BPM-024

PROGRAMMING EQUIPMENT

Generic programming boards and device adapters are available from the sources listed below. In each case, the programming boards are used in these manufacturer's automatic

programmers to program all AMD generic series bipolar PROMs; individual adapters are required for each basic part type in the series.

|   |   |  |
|---|---|--|
| SOURCE AND LOCATION                         | Data I/O Corp.<br>P.O. Box 308<br>Issaquah, Wash. 98027 | Pro-Log Corp.<br>2411 Garden Road<br>Monterey, Ca. 93940 |
| PROGRAMMER MODEL(S)                         | Model 5, 7 and 9  | M900 and M920  |
| AMD GENERIC BIPOLAR PROM PERSONALITY BOARD  | 909-1286-1  | PM9058   |
| Am27S18 • Am27S19 ADAPTERS AND CONFIGURATOR | 715-1407-1  | PA16-6 and 32 x 8 (L)                                    |

OBTAINING PROGRAMMED UNITS

Programmed devices may be purchased from your distributor or Advanced Micro Devices. The program data should be submitted in the form of a punched paper tape and must be accompanied by a written truth table. The punched tape can be delivered with your order or may be transmitted over a TWX machine or time-sharing terminal. ASCII BPNF is our preferred paper tape format.

Truth tables are also acceptable, but are much less desirable especially for larger density PROMs. Submission of a truth table requires the generation of a punched paper tape at the distributor or factory resulting in longer lead times, greater possibility of error, and higher cost.

ASCII BPNF

An example of an ASCII tape in the BPNF format is shown below. They can be punched on any Teletype® or on a TWX or Telex machine. The format chosen provides relatively good error detection. Paper tapes must consist of:

- 1. A leader of at least 25 rubouts.
- 2. The data patterns for all 32 words, starting with word 0, in the following format:
  - a. Any characters, including carriage return and line feed, except "B".
  - b. The letter "B", indicating the beginning of the data word.
  - c. A sequence of eight Ps or Ns, starting with output O<sub>7</sub>.
  - d. The letter "F", indicating the finish of the data word.
  - e. Any text, including carriage return and line feed, except the letter "B".

- 3. A trailer of at least 25 rubouts.
- A P is a HIGH logic level = 2.4 volts.
- An N is a LOW logic level = 0.4 volts.

A convenient pattern to use for the data words is to prefix the word (or every few words with the word number, then type the data word, then a comment, then carriage return and line feed as shown below. There must be no characters between the B and the F except for the eight Ps and Ns. If an error is made in a word, the entire word must be cancelled with rubouts back to the letter B, then the word re-typed beginning with the B.

When TWXing your tape, be sure the tape is in even parity. Parity is not necessary if the tape is mailed.

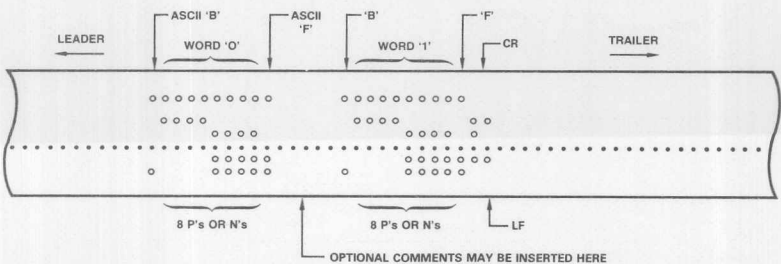
TYPICAL PAPER TAPE FORMAT

⌀⌀⌀ BPNPNNNFF WORD ZERO (R) (L)  
BPPPPPPNFF COMMENT FIELD (R) (L)  
⌀⌀2 BNNPPPPNFF ANY (R) (L)  
BNNNNNNNFF TEXT (R) (L)  
⌀⌀4 BPNNNNNNFF CAN (R) (L)  
BNPPNPPNFF GO (R) (L)  
⌀⌀6 BPNPPPPNFF HERE (R) (L)  
⋮  
⌀31 BNNNNPPPPNFF END (R) (L)  
(R) = CARRIAGE RETURN  
(L) = LINE FEED

RESULTING DEVICE TRUTH TABLE (CS = LOW)

| A <sub>4</sub> | A <sub>3</sub> | A <sub>2</sub> | A <sub>1</sub> | A <sub>0</sub> | O <sub>7</sub> | O <sub>6</sub> | O <sub>5</sub> | O <sub>4</sub> | O <sub>3</sub> | O <sub>2</sub> | O <sub>1</sub> | O <sub>0</sub> |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| L              | L              | L              | L              | L              | H              | L              | H              | H              | L              | L              | L              | H              |
| L              | L              | L              | L              | H              | H              | H              | H              | H              | H              | H              | L              | L              |
| L              | L              | L              | H              | L              | L              | L              | L              | H              | H              | H              | H              | L              |
| L              | L              | L              | H              | H              | L              | L              | L              | L              | L              | L              | L              | L              |
| L              | L              | H              | L              | L              | H              | L              | L              | L              | L              | L              | L              | H              |
| L              | L              | H              | L              | H              | L              | H              | H              | L              | H              | H              | L              | L              |
| L              | L              | H              | H              | L              | H              | L              | L              | H              | H              | H              | L              | L              |
| ⋮              | ⋮              | ⋮              | ⋮              | ⋮              | ⋮              | ⋮              | ⋮              | ⋮              | ⋮              | ⋮              | ⋮              | ⋮              |
| H              | H              | H              | H              | H              | L              | L              | L              | L              | H              | H              | H              | L              |

ASCII PAPER TAPE



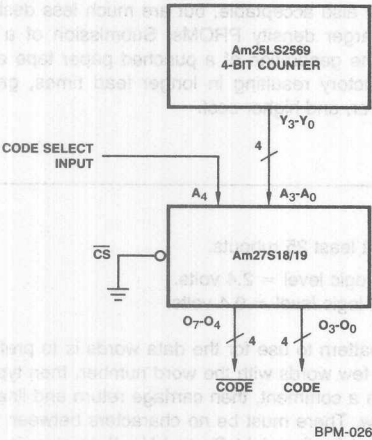
APPLYING THE Am27S18 AND Am27S19

The Am27S18 and Am27S19 PROMs may be used as code converters. Examples include conversion of hexadecimal, octal or BCD to seven segment display drive format. In many code conversion applications an extra PROM address input is available and may be used as a polarity control, blanking con-

trol or code selector input. The use of a single Am27S18 or Am27S19 to convert the outputs of a binary counter to either excess three or gray code format is illustrated below. In this case both codes are generated in true and complemented form simultaneously.

TRUTH TABLE

| ADDRESS        |                |                |                |                | COMPLEMENT     |                |                |                | TRUE           |                |                |                |                   |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|-------------------|
| A <sub>4</sub> | A <sub>3</sub> | A <sub>2</sub> | A <sub>1</sub> | A <sub>0</sub> | O <sub>7</sub> | O <sub>6</sub> | O <sub>5</sub> | O <sub>4</sub> | O <sub>3</sub> | O <sub>2</sub> | O <sub>1</sub> | O <sub>0</sub> |                   |
| 0              | 0              | 0              | 0              | 0              | 1              | 1              | 0              | 0              | 0              | 0              | 1              | 1              | EXCESS THREE CODE |
| 0              | 0              | 0              | 0              | 1              | 1              | 0              | 1              | 1              | 0              | 1              | 0              | 0              |                   |
| 0              | 0              | 0              | 1              | 0              | 1              | 0              | 1              | 0              | 0              | 1              | 0              | 1              |                   |
| 0              | 0              | 0              | 1              | 1              | 1              | 0              | 0              | 1              | 0              | 1              | 1              | 0              |                   |
| 0              | 0              | 1              | 0              | 0              | 1              | 0              | 0              | 0              | 0              | 1              | 1              | 1              |                   |
| 0              | 0              | 1              | 0              | 1              | 0              | 1              | 1              | 1              | 1              | 0              | 0              | 0              |                   |
| 0              | 0              | 1              | 1              | 0              | 0              | 1              | 1              | 0              | 1              | 0              | 0              | 1              |                   |
| 0              | 0              | 1              | 1              | 1              | 0              | 1              | 0              | 1              | 0              | 1              | 0              | 1              |                   |
| 0              | 1              | 0              | 0              | 0              | 0              | 1              | 0              | 0              | 1              | 0              | 1              | 1              |                   |
| 0              | 1              | 0              | 0              | 1              | 0              | 0              | 1              | 1              | 1              | 1              | 0              | 0              |                   |
| 0              | 1              | 0              | 1              | 0              | X              | X              | X              | X              | X              | X              | X              | X              |                   |
| 0              | 1              | 0              | 1              | 1              | X              | X              | X              | X              | X              | X              | X              | X              |                   |
| 0              | 1              | 1              | 0              | 0              | X              | X              | X              | X              | X              | X              | X              | X              |                   |
| 0              | 1              | 1              | 0              | 1              | X              | X              | X              | X              | X              | X              | X              | X              |                   |
| 0              | 1              | 1              | 1              | 0              | X              | X              | X              | X              | X              | X              | X              | X              |                   |
| 1              | 0              | 0              | 0              | 0              | 1              | 1              | 1              | 1              | 0              | 0              | 0              | 0              | GRAY CODE         |
| 1              | 0              | 0              | 0              | 1              | 1              | 1              | 1              | 0              | 0              | 0              | 0              | 1              |                   |
| 1              | 0              | 0              | 1              | 0              | 1              | 1              | 0              | 0              | 0              | 0              | 1              | 1              |                   |
| 1              | 0              | 0              | 1              | 1              | 1              | 1              | 0              | 1              | 0              | 0              | 1              | 0              |                   |
| 1              | 0              | 1              | 0              | 0              | 1              | 0              | 0              | 1              | 0              | 1              | 1              | 0              |                   |
| 1              | 0              | 1              | 0              | 1              | 1              | 0              | 0              | 0              | 0              | 1              | 1              | 1              |                   |
| 1              | 0              | 1              | 1              | 0              | 1              | 0              | 1              | 0              | 0              | 1              | 0              | 1              |                   |
| 1              | 0              | 1              | 1              | 1              | 1              | 0              | 1              | 1              | 0              | 1              | 0              | 0              |                   |
| 1              | 1              | 0              | 0              | 0              | 0              | 0              | 1              | 1              | 1              | 1              | 0              | 0              |                   |
| 1              | 1              | 0              | 0              | 1              | 0              | 0              | 1              | 0              | 1              | 1              | 0              | 1              |                   |
| 1              | 1              | 0              | 1              | 0              | 0              | 0              | 0              | 0              | 1              | 1              | 1              | 1              |                   |
| 1              | 1              | 0              | 1              | 1              | 0              | 0              | 0              | 1              | 1              | 1              | 1              | 0              |                   |
| 1              | 1              | 1              | 0              | 0              | 0              | 1              | 0              | 1              | 1              | 0              | 1              | 0              |                   |
| 1              | 1              | 1              | 0              | 1              | 0              | 1              | 0              | 0              | 1              | 0              | 1              | 1              |                   |
| 1              | 1              | 1              | 1              | 0              | 0              | 1              | 1              | 0              | 1              | 0              | 0              | 1              |                   |
| 1              | 1              | 1              | 1              | 1              | 0              | 1              | 1              | 1              | 1              | 0              | 0              | 0              |                   |





# Am27S20 • Am27S21

## 1024-Bit Generic Series Bipolar PROM

### DISTINCTIVE CHARACTERISTICS

- High Speed – 45ns max commercial range access time
- Excellent performance over full MIL and commercial ranges
- Highly reliable, ultra-fast programming Platinum-Silicide fuses
- High programming yield
- Low current PNP inputs
- High current open collector and three-state outputs
- Fast chip select
- Access time tested with  $N^2$  patterns
- Pin for pin replacements for industry standard products
- Common Generic PROM series electrical characteristics and simple programming procedures.

### GENERIC SERIES CHARACTERISTICS

The Am27S20 and Am27S21 are members of an Advanced PROM series incorporating common electrical characteristics and programming procedures. All parts in this series are produced with a fusible link at each memory location storing a logic LOW and can be selectively programmed to a logic HIGH by applying appropriate voltages to the circuit.

All parts are fabricated with AMD's fast programming highly reliable Platinum-Silicide Fuse technology. Utilizing easily implemented programming (and common programming personality card sets) these products can be rapidly programmed to any customized pattern. Extra test words are pre-programmed during manufacturing to insure extremely high field programming yields, and produce excellent parametric correlation.

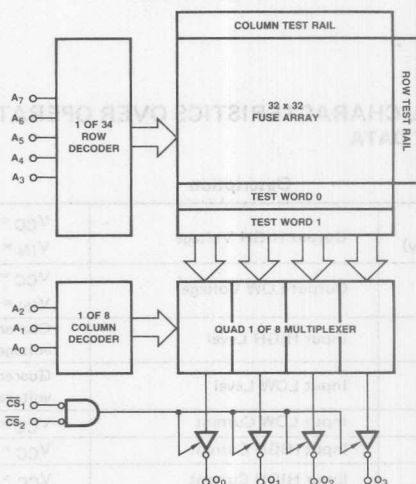
Platinum-Silicide was selected as the fuse link material to achieve a well controlled melt rate resulting in large non-conductive gaps that ensure very stable long term reliability. Extensive operating testing has proven that this low-field, large-gap technology offers the best reliability for fusible link PROMs.

Common design features include active loading of all critical AC paths regulated by a built-in temperature and voltage compensated bias network to provide excellent parametric performance over MIL supply and temperature ranges. Selective feedback techniques have been employed to minimize delays through all critical paths producing the fastest speeds possible from Schottky processed PROMs.

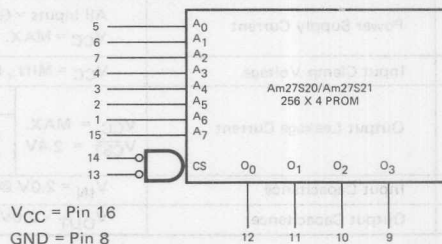
### FUNCTIONAL DESCRIPTION

The Am27S20 and Am27S21 are high speed electrically programmable Schottky read only memories. Organized in the industry standard  $256 \times 4$  configuration, they are available in both open collector Am27S20 and three-state Am27S21 output versions. After programming, stored information is read on outputs  $O_0$ – $O_3$  by applying unique binary addresses to  $A_0$ – $A_7$  and holding the chip select inputs,  $\overline{CS}_1$  and  $\overline{CS}_2$ , at a logic LOW. If either chip select input goes to a logic HIGH,  $O_0$ – $O_3$  go to the off or high impedance state.

### BLOCK DIAGRAM



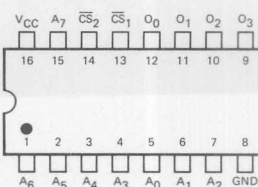
### LOGIC SYMBOL



### ORDERING INFORMATION

| Package Type        | Temperature Range | Order Number |
|---------------------|-------------------|--------------|
| Open Collectors     |                   |              |
| Hermetic DIP        | 0°C to +75°C      | AM27S20DC    |
| Hermetic DIP        | –55°C to +125°C   | AM27S20DM    |
| Hermetic Flat Pak   | –55°C to +125°C   | AM27S20FM    |
| Three-State Outputs |                   |              |
| Hermetic DIP        | 0°C to +75°C      | AM27S21DC    |
| Hermetic DIP        | –55°C to +125°C   | AM27S21DM    |
| Hermetic Flat Pak   | –55°C to +125°C   | AM27S21FM    |

### CONNECTION DIAGRAM Top View



Note: Pin 1 is marked for orientation.



# Am27S20 • Am27S21

## MAXIMUM RATINGS (Above which the useful life may be impaired)

|  |                                |
|--|--------------------------------|
| Storage Temperature  | -65°C to +150°C                |
| Temperature (Ambient) Under Bias   | -55°C to +125°C                |
| Supply Voltage to Ground Potential (Pin 16 to Pin 8) Continuous          | -0.5V to +7.0V                 |
| DC Voltage Applied to Outputs (Except During Programming)                | -0.5V to +V <sub>CC</sub> max. |
| DC Voltage Applied to Outputs During Programming                         | 21V                            |
| Output Current into Outputs During Programming (Max. Duration of 1 sec.) | 200mA                          |
| DC Input Voltage   | -0.5V to +5.5V                 |
| DC Input Current   | -30mA to +5mA                  |

## OPERATING RANGE

|       |                      |                                  |                             |
|-------|----------------------|----------------------------------|-----------------------------|
| COM'L | Am27S20XC, Am27S21XC | T <sub>A</sub> = 0°C to +75°C    | V <sub>CC</sub> = 5.0V ±5%  |
| MIL   | Am27S20XM, Am27S21XM | T <sub>A</sub> = -55°C to +125°C | V <sub>CC</sub> = 5.0V ±10% |

## ELECTRICAL CHARACTERISTICS OVER OPERATING RANGE (Unless Otherwise Noted) PRELIMINARY DATA

| Parameters                        | Description                  | Test Conditions  | Min. | Typ.<br>(Note 1) | Max.   | Units |
|-----------------------------------|------------------------------|--|------|------------------|--------|-------|
| V <sub>OH</sub><br>(Am27S21 only) | Output HIGH Voltage          | V <sub>CC</sub> = MIN., I <sub>OH</sub> = -2.0mA<br>V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub> | 2.4  |                  |        | Volts |
| V <sub>OL</sub>                   | Output LOW Voltage           | V <sub>CC</sub> = MIN., I <sub>OL</sub> = 16mA<br>V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>   |      |                  | 0.45   | Volts |
| V <sub>IH</sub>                   | Input HIGH Level             | Guaranteed input logical HIGH voltage for all inputs   | 2.0  |                  |        | Volts |
| V <sub>IL</sub>                   | Input LOW Level              | Guaranteed input logical LOW voltage for all inputs  |      |                  | 0.8    | Volts |
| I <sub>IL</sub>                   | Input LOW Current            | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 0.45V  |      | -0.010           | -0.250 | mA    |
| I <sub>IH</sub>                   | Input HIGH Current           | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 2.7V   |      |                  | 25     | μA    |
| I <sub>I</sub>                    | Input HIGH Current           | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 5.5V   |      |                  | 1.0    | mA    |
| I <sub>SC</sub><br>(Am27S21 only) | Output Short Circuit Current | V <sub>CC</sub> = MAX., V <sub>OUT</sub> = 0.0V (Note 2)   | -20  | -40              | -90    | mA    |
| I <sub>CC</sub>                   | Power Supply Current         | All inputs = GND<br>V <sub>CC</sub> = MAX.   |      | 95               | 130    | mA    |
| V <sub>I</sub>                    | Input Clamp Voltage          | V <sub>CC</sub> = MIN., I <sub>IN</sub> = -18mA  |      |                  | -1.2   | Volts |
| I <sub>CEX</sub>                  | Output Leakage Current       | V <sub>CC</sub> = MAX.<br>V <sub>CS1</sub> = 2.4V  |      |                  | 40     | μA    |
|                                   |                              | Am27S21 only   |      |                  | 40     |       |
|                                   |                              |  |      |                  | -40    |       |
| C <sub>IN</sub>                   | Input Capacitance            | V <sub>IN</sub> = 2.0V @ f = 1 MHz (Note 3)  |      | 4                |        | pF    |
| C <sub>OUT</sub>                  | Output Capacitance           | V <sub>OUT</sub> = 2.0V @ f = 1 MHz (Note 3)   |      | 8                |        | pF    |

Note 1. Typical limits are at V<sub>CC</sub> = 5.0V and T<sub>A</sub> = 25°C

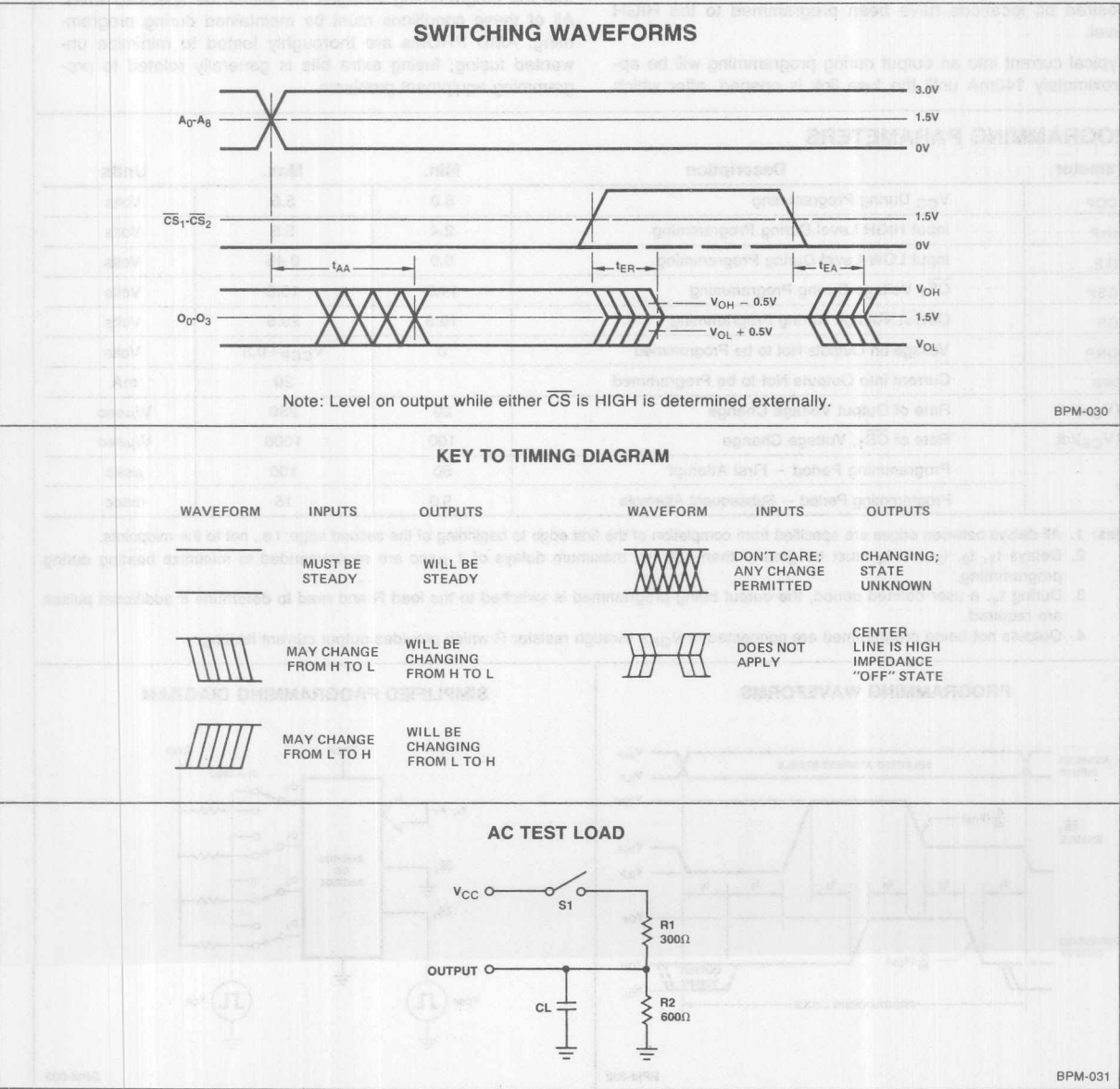
2. Not more than one output should be shorted at a time. Duration of the short circuit should not be more than one second.

3. These parameters are not 100% tested, but are periodically sampled.

SWITCHING CHARACTERISTICS OVER OPERATING RANGE  
PRELIMINARY DATA

| Parameter       | Description          | Test Conditions                 | Typ        | Max   |     | Units |
|-----------------|----------------------|---------------------------------|------------|-------|-----|-------|
|                 |                      |                                 | 5V<br>25°C | COM'L | MIL |       |
| t <sub>AA</sub> | Address Access Time  | AC Test Load<br>(See Notes 1-3) | 25         | 45    | 60  | ns    |
| t <sub>EA</sub> | Enable Access Time   |                                 | 15         | 20    | 30  | ns    |
| t <sub>ER</sub> | Enable Recovery Time |                                 | 15         | 20    | 30  | ns    |

- Notes: 1. t<sub>AA</sub> is tested with switch S<sub>1</sub> closed and C<sub>L</sub> = 30pF.  
2. For open collector outputs, t<sub>EA</sub> and t<sub>ER</sub> are tested with S<sub>1</sub> closed to the 1.5V output level. C<sub>L</sub> = 30pF.  
3. For three state outputs, t<sub>EA</sub> is tested with C<sub>L</sub> = 30pF to the 1.5V level; S<sub>1</sub> is open for high impedance to HIGH tests and closed for high impedance to LOW tests. t<sub>ER</sub> is tested with C<sub>L</sub> = 5pF. HIGH to high impedance tests are made with S<sub>1</sub> open to an output voltage of V<sub>OH</sub> - 0.5V; LOW to high impedance tests are made with S<sub>1</sub> closed to the V<sub>OL</sub> + 0.5V level.



## PROGRAMMING

The Am27S20 and Am27S21 are manufactured with a conductive Platinum-Silicide link at each bit location. The output of the memory with the link in place is LOW. To program the device, the fusible links are selectively opened.

The fusible links are opened one at a time by passing current through them from a 20 volt supply which is applied to one memory output after the  $\overline{CS}_1$  input is at a logic HIGH. Current is gated through the addressed fuse by raising the  $\overline{CS}_1$  input from a logic HIGH to 15 volts. After 50  $\mu$ sec, the 20 volt supply is removed, the chip enabled, and the output level sensed to determine if the link has opened. Most links will open within 50  $\mu$ sec. Occasionally a link will be stronger and require additional programming cycles. The recommended duration of additional programming periods is 5 msec. If a link has not opened after a total elapsed programming time of 400 msec, further programming of the device should not be attempted. Successive links are programmed in the same manner until all desired bit locations have been programmed to the HIGH level.

Typical current into an output during programming will be approximately 140mA until the fuse link is opened, after which

the current drops to approximately 40mA. Current into the  $\overline{CS}_1$  pin when it is raised to 15 volts is typically 1.5mA.

The memories may become hot during programming due to the large currents being passed. Programming cycles should not be applied to one device more than 5 seconds to avoid heat damage. If this programming time is exceeded, all power to the chip including  $V_{CC}$  should be removed for a period of 5 seconds after which programming may be resumed.

When all programming has been completed, the data content of the memory should be verified by sequentially reading all words. Occasionally this verification will show that an extra undesired link has been fused. Should this occur, immediately check the programming equipment to make sure that all device pins are firmly contacting the programming socket, that the input signal levels exhibit sufficient noise margins, and that the programming voltages are within the specified limits. All of these conditions must be maintained during programming. AMD PROMs are thoroughly tested to minimize unwanted fusing; fusing extra bits is generally related to programming equipment problems.

## PROGRAMMING PARAMETERS

| Parameter      | Description                                  | Min. | Max.            | Units        |
|----------------|--|------|-----------------|--------------|
| $V_{CCP}$      | $V_{CC}$ During Programming                  | 5.0  | 5.5             | Volts        |
| $V_{IHP}$      | Input HIGH Level During Programming          | 2.4  | 5.5             | Volts        |
| $V_{ILP}$      | Input LOW Level During Programming           | 0.0  | 0.45            | Volts        |
| $V_{CSP}$      | $\overline{CS}_1$ Voltage During Programming | 14.5 | 15.5            | Volts        |
| $V_{OP}$       | Output Voltage During Programming            | 19.5 | 20.5            | Volts        |
| $V_{ONP}$      | Voltage on Outputs Not to be Programmed      | 0    | $V_{CCP} + 0.3$ | Volts        |
| $I_{ONP}$      | Current into Outputs Not to be Programmed    |      | 20              | mA           |
| $d(V_{OP})/dt$ | Rate of Output Voltage Change                | 20   | 250             | V/ $\mu$ sec |
| $d(V_{CS})/dt$ | Rate of $\overline{CS}_1$ , Voltage Change   | 100  | 1000            | V/ $\mu$ sec |
| $t_P$          | Programming Period – First Attempt           | 50   | 100             | $\mu$ sec    |
|                | Programming Period – Subsequent Attempts     | 5.0  | 15              | msec         |

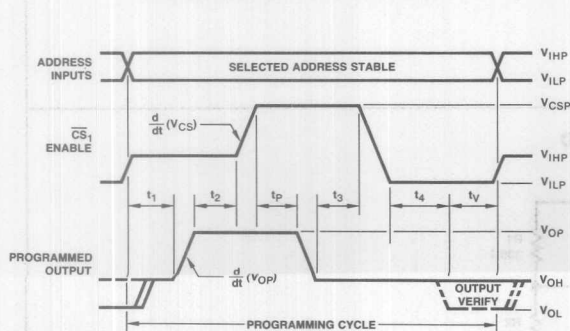
Notes: 1. All delays between edges are specified from completion of the first edge to beginning of the second edge; i.e., not to the midpoints.

2. Delays  $t_1$ ,  $t_2$ ,  $t_3$  and  $t_4$  must be greater than 100 ns; maximum delays of 1  $\mu$ sec are recommended to minimize heating during programming.

3. During  $t_v$ , a user defined period, the output being programmed is switched to the load R and read to determine if additional pulses are required.

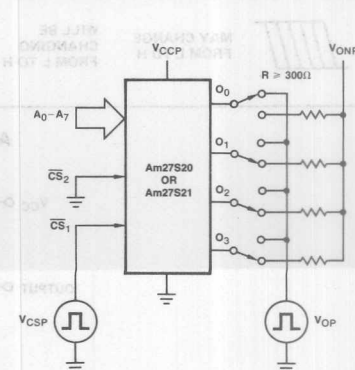
4. Outputs not being programmed are connected to  $V_{ONP}$  through resistor R which provides output current limiting.

## PROGRAMMING WAVEFORMS



BPM-032

## SIMPLIFIED PROGRAMMING DIAGRAM



BPM-033

| SOURCE AND LOCATION | Date |
|---------------------|------|
| P.O.                |      |
| Issa                |      |

|             |                     |
|-------------|---------------------|
| Corp.       | Pro-Log Corp.       |
| 308         | 2411 Garden Road    |
| Wash. 98027 | Monterey, Ca. 93940 |

715-1408-1

ASCII BPWF

1. A leader of at least 25 rubouts.
2. The data patterns for all 256 words, starting with word 0, in

- TYPICAL PAPER TAPE FORMAT**

An N is a LOW logic level = 0.4 volts

When TWXing your tape, be sure the tape is in even parity.

RESULTING DEVICE TRUTH TABLE ( $\overline{CS}_1$  &  $\overline{CS}_2$  = LOW)

**RESULTING DEVICE TRUTH TABLE ( $\overline{\text{CS}}_1$  &  $\overline{\text{CS}}_2 = \text{LOW}$ )**

004 BNNNNF TEXT (R) (L)  
BNNNPF CAN (R) (L)  
BPPNNF GO (R) (L)  
006 BPPNNF HERE (R) (L)

|   |   |   |   |   |   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|---|---|---|---|---|
| L | L | L | L | L | L | H | H | L | L | L | L |
| L | L | L | L | L | H | L | L | L | L | L | H |
| L | L | L | L | L | H | L | H | H | H | L | L |

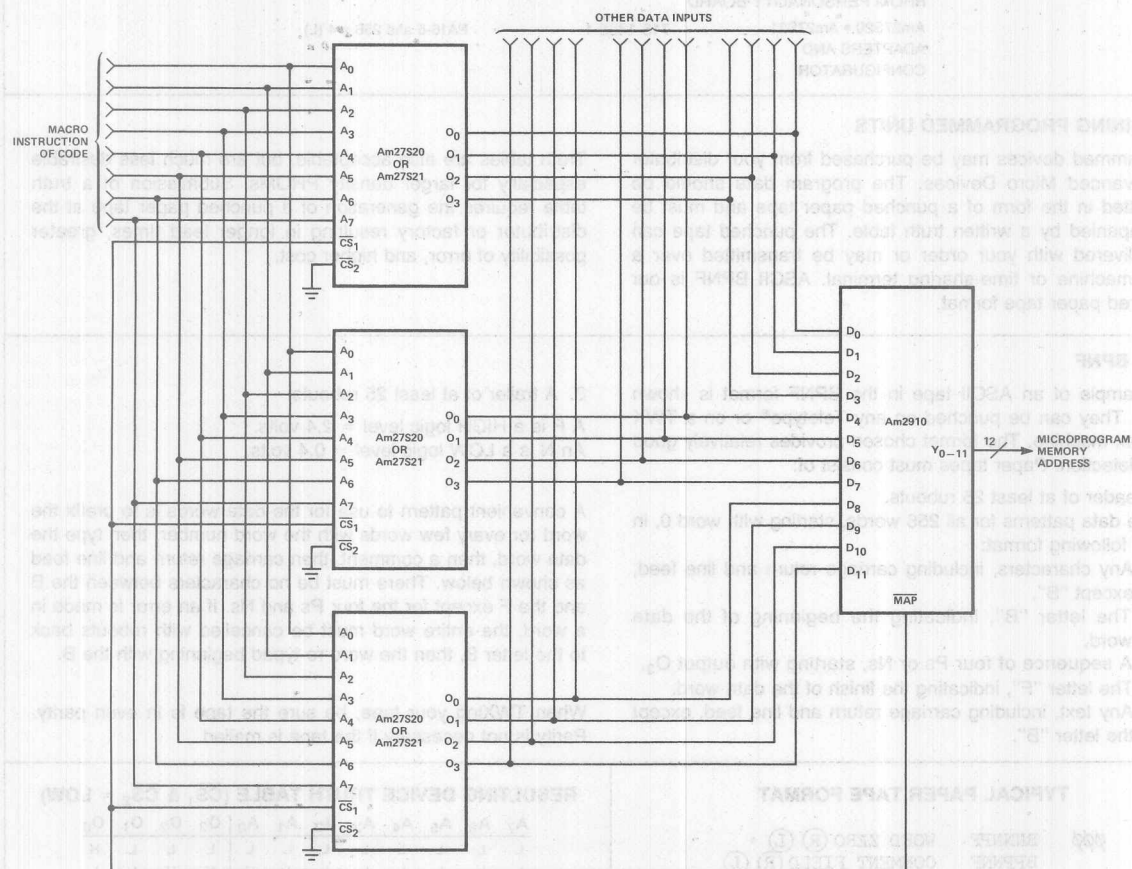




## APPLYING THE Am27S20/21

Typical application of the Am27S20/21 is shown below. The Am27S20/21's are employed as mapping ROMs in a microprogram computer control unit. The eight-bit macroinstruction from main memory is brought into the  $A_{0-7}$  inputs of the mapping ROM array. The instruction is mapped into a 12-bit address space with each PROM output supplying 4 bits. The 12 bits of address are then supplied to the "D" inputs of the Am2910 as a possible next address source for microprogram

memory. The  $\overline{\text{MAP}}$  output of the Am2910 is connected to the  $\overline{\text{CS}}_1$  input of the Am27S20/21 such that when the  $\overline{\text{CS}}_1$  input is HIGH, the outputs of the PROMs are either HIGH in the case of the Am27S20 or in the three-state mode in the case of the Am27S21. In both cases the  $\overline{\text{CS}}_2$  input is grounded, thus data from other sources are free to drive the D inputs of the Am2910 when MAP is HIGH.



MICROPROGRAMMING INSTRUCTION MAPPING

BPM-035



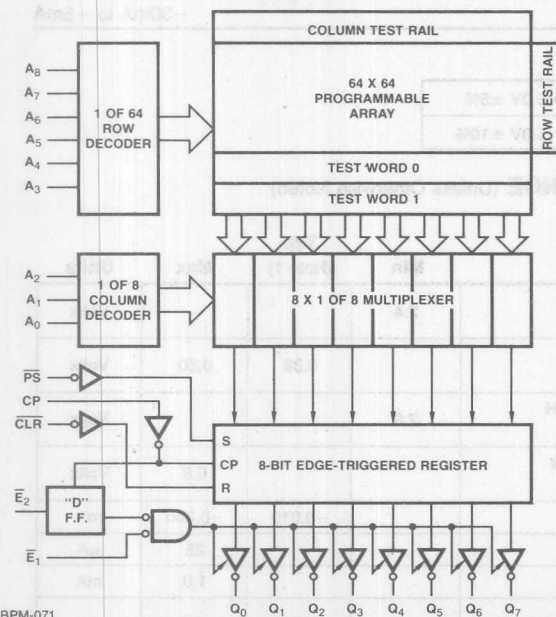
# Am27S25

## 4096-Bit Generic Series Bipolar PROM

### DISTINCTIVE CHARACTERISTICS

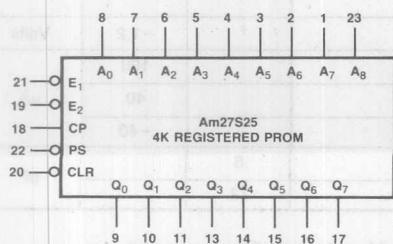
- On chip edge triggered registers — Ideal for pipelined microprogrammed systems
- Versatile synchronous and asynchronous enables for simplified word expansion
- Buffered common asynchronous PRESET and CLEAR inputs
- Space saving 24-pin package with 300 mil lateral centers
- Predetermined OFF outputs on power-up
- Fast 50ns address setup and 20ns clock to output times
- Excellent performance over the military range
- Performance pretested with N<sup>2</sup> patterns
- Highly reliable, ultra-fast programming Platinum-Silicide fuses
- High programming yield
- Low current PNP inputs
- High current three-state outputs
- Common Generic PROM Series characteristics and programming procedures

### BLOCK DIAGRAM



BPM-071

### LOGIC SYMBOL



BPM-072

V<sub>CC</sub> = Pin 24  
GND = Pin 12

### FUNCTIONAL DESCRIPTION

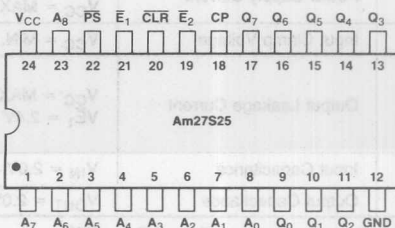
The Am27S25 is an electrically programmable Schottky TTL read only memory incorporating true D-type, master-slave data registers on chip. This device features the versatile 512 word by 8 bit organization and is available in the three-state Am27S25 output version. Designed to optimize system performance, this device also substantially reduces the cost and size of pipelined microprogrammed systems and other designs wherein accessed PROM data is temporarily stored in a register. The Am27S25 also offers maximal flexibility for memory expansion and data bus control by providing both synchronous and asynchronous output enables.

When V<sub>CC</sub> power is first applied, the synchronous enable ( $\bar{E}_2$ ) flip-flop will be in the set condition causing the outputs, Q<sub>0</sub>-Q<sub>7</sub>, to be in the OFF or high impedance state. Reading data is accomplished by first applying the binary word address to the address inputs, A<sub>0</sub>-A<sub>8</sub>, and a logic LOW to the synchronous output enable,  $\bar{E}_2$ . During the address setup time, stored data is accessed and loaded into the master flip-flops of the data register. Since the synchronous enable setup time is less than the address setup requirement, additional decoding delays may occur in the enable path without reducing memory performance. Upon the next LOW-to-HIGH transition of the clock, CP, data is transferred to the slave flip-flops which drive the output buffers. Providing the asynchronous enable,  $\bar{E}_1$ , is also LOW, stored data will appear on the outputs, Q<sub>0</sub>-Q<sub>7</sub>. If  $\bar{E}_2$  is HIGH when the positive clock edge occurs, outputs go to the OFF or high impedance state. The outputs may be disabled at any time by switching  $\bar{E}_1$  to a HIGH level. Following the positive clock edge, the address and synchronous enable inputs are free to change; changes do not affect the outputs until another positive clock edge occurs. This unique feature allows the PROM decoders and sense amplifiers to access the next location while previously addressed data remains stable on the outputs. For less complex applications either enable may be effectively eliminated by tying it to ground.

The on-chip, edge triggered register simplifies system timing since the PROM clock may be derived directly from system clock without introducing dangerous race conditions. Other register timing requirements are similar to those of standard Schottky registers and are easily implemented.

The Am27S25 has buffered asynchronous PRESET and CLEAR inputs. These functions are common to all registers and are useful during power up timeout sequences. With outputs enabled the PS input asserted LOW will cause all outputs to be set to a logic 1 (HIGH) state. When the CLR input is LOW, the internal flip-flops of the data register are reset and, a logic 0 (LOW) will appear on all outputs. These functions will control the state of the data register, independent of all other inputs but exclusive of each other.

### CONNECTION DIAGRAM — Top View



Note: Pin 1 is marked for orientation.

BPM-073

## GENERIC SERIES CHARACTERISTICS

The Am27S25 is a member of an Advanced PROM series incorporating common electrical characteristics and programming procedures. All parts in this series are produced with a fusible link at each memory location storing a logic LOW and can be selectively programmed to a logic HIGH by applying appropriate voltages to the circuit.

All parts are fabricated with AMD's fast programming highly reliable Platinum-Silicide Fuse technology. Utilizing easily implemented programming (and common programming personality card sets) these products can be rapidly programmed to any customized pattern. Extra test words are pre-programmed during manufacturing to insure extremely high field programming yields, and produce excellent parametric correlation.

Platinum-Silicide was selected as the fuse link material to achieve a well controlled melt rate resulting in large non-conductive gaps that ensure very stable long term reliability. Extensive operating testing has proven that this low-field, large-gap technology offers the best reliability for fusible link PROMs.

Common design features include active loading of all critical AC paths regulated by a built-in temperature and voltage compensated bias network to provide excellent parametric performance over MIL supply and temperature ranges. Selective feedback techniques have been employed to minimize delays through all critical paths producing the fastest speeds possible from Schottky processed PROMs.

## MAXIMUM RATINGS (Above which the useful life may be impaired)

|  |                                |
|--|--------------------------------|
| Storage Temperature  | -65°C to +150°C                |
| Temperature (Ambient) Under Bias   | -55°C to +125°C                |
| Supply Voltage to Ground Potential (Pin 24 to Pin 12) Continuous         | -0.5V to +7.0V                 |
| DC Voltage Applied to Outputs (Except During Programming)                | -0.5V to +V <sub>CC</sub> max. |
| DC Voltage Applied to Outputs During Programming                         | 21V                            |
| Output Current into Outputs During Programming (Max. Duration of 1 sec.) | 200mA                          |
| DC Input Voltage   | -0.5V to +5.5V                 |
| DC Input Current   | -30mA to +5mA                  |

## OPERATING RANGE

|       |           |                                |                             |
|-------|-----------|--------------------------------|-----------------------------|
| COM'L | AM27S25XC | T <sub>A</sub> = 0 to 75°C     | V <sub>CC</sub> = 5.0V ±5%  |
| MIL   | AM27S25XM | T <sub>C</sub> = -55 to +125°C | V <sub>CC</sub> = 5.0V ±10% |

ELECTRICAL CHARACTERISTICS OVER OPERATING RANGE (Unless Otherwise Noted)  
PRELIMINARY DATA

| Parameters       | Description                  | Test Conditions  | Typ |          | Max    | Units |
|------------------|------------------------------|--|-----|----------|--------|-------|
|                  |                              |  | Min | (Note 1) |        |       |
| V <sub>OH</sub>  | Output HIGH Voltage          | V <sub>CC</sub> = MIN., I <sub>OH</sub> = -2.0mA<br>V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub> | 2.4 |          |        | Volts |
| V <sub>OL</sub>  | Output LOW Voltage           | V <sub>CC</sub> = MIN., I <sub>OL</sub> = 16mA<br>V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>   |     | 0.38     | 0.50   | Volts |
| V <sub>IH</sub>  | Input HIGH Level             | Guaranteed input logical HIGH voltage for all inputs   | 2.0 |          |        | Volts |
| V <sub>IL</sub>  | Input LOW Level              | Guaranteed input logical LOW voltage for all inputs  |     |          | 0.8    | Volts |
| I <sub>IL</sub>  | Input LOW Current            | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 0.45V  |     | -0.010   | -0.250 | mA    |
| I <sub>IH</sub>  | Input HIGH Current           | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 2.7V   |     |          | 25     | μA    |
| I <sub>I</sub>   | Input HIGH Current           | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 5.5V   |     |          | 1.0    | mA    |
| I <sub>SC</sub>  | Output Short Circuit Current | V <sub>CC</sub> = MAX., V <sub>OUT</sub> = 0.0V (Note 2)   | -20 | -40      | -90    | mA    |
| I <sub>CC</sub>  | Power Supply Current         | All inputs = GND<br>V <sub>CC</sub> = MAX.   |     | 130      | 185    | mA    |
| V <sub>I</sub>   | Input Clamp Voltage          | V <sub>CC</sub> = MIN., I <sub>IN</sub> = -18mA  |     |          | -1.2   | Volts |
| I <sub>CEX</sub> | Output Leakage Current       | V <sub>CC</sub> = MAX.<br>V <sub>E1</sub> = 2.4V   |     |          | 100    | μA    |
|                  |                              |  |     |          | 40     |       |
|                  |                              |  |     |          | -40    |       |
| C <sub>IN</sub>  | Input Capacitance            | V <sub>IN</sub> = 2.0V @ f = 1MHz (Note 3)   |     | 5        |        | pF    |
| C <sub>OUT</sub> | Output Capacitance           | V <sub>OUT</sub> = 2.0V @ f = 1MHz (Note 3)  |     | 12       |        |       |

Notes: 1. Typical limits are at V<sub>CC</sub> = 5.0V and T<sub>A</sub> = 25°C.

2. Not more than one output should be shorted at a time. Duration of the short circuit should not be more than one second.

3. These parameters are not 100% tested, but are periodically sampled.

**SWITCHING CHARACTERISTICS OVER OPERATING RANGE**  
**PRELIMINARY DATA**
 $T_A = 25^\circ\text{C}$  $V_{CC} = 5.0\text{V}$ 

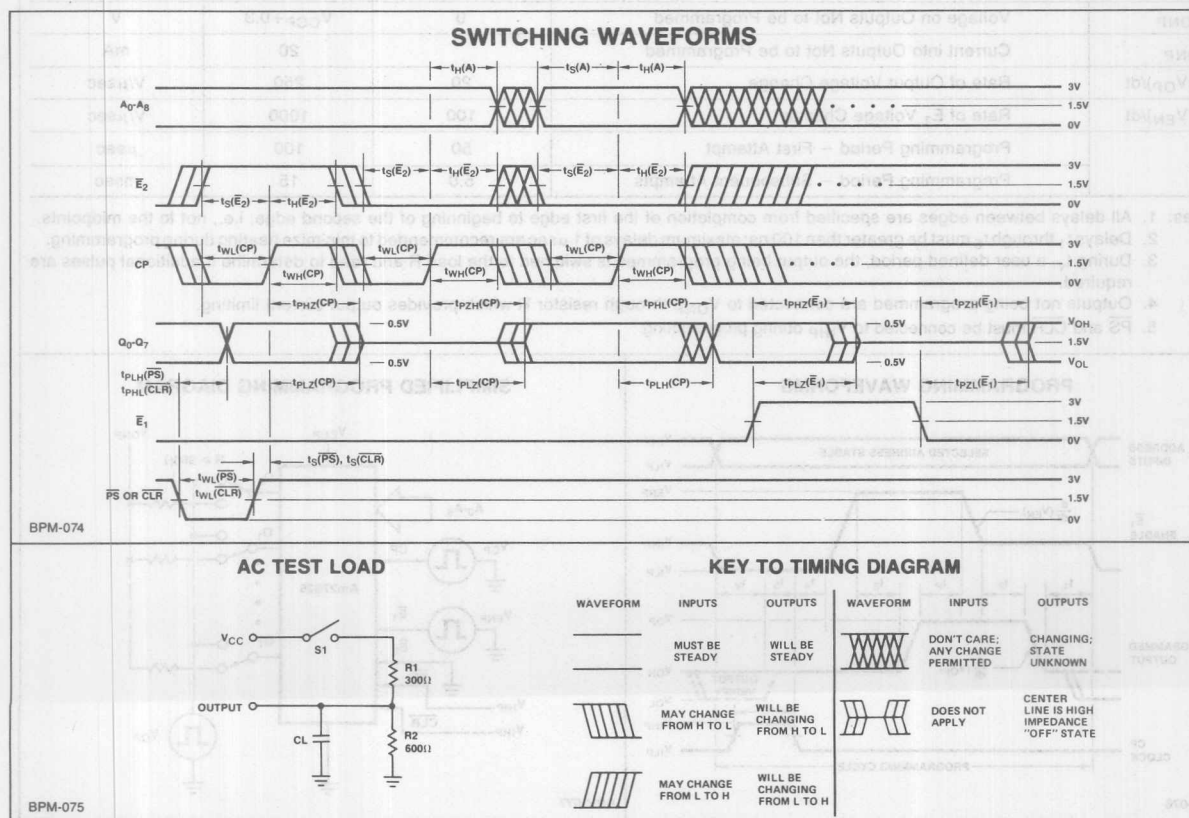
COM'L

MIL

| Parameter                                    | Description  | Test Conditions   | Typ | Min | Max | Min | Max | Units |
|--|--|---|-----|-----|-----|-----|-----|-------|
| $t_{S(A)}$                                   | Address to CP (HIGH) Setup Time  | $C_L = 30\text{pF}$<br>$S_1$ closed.<br>(See AC Test Load below)                    | 35  |     |     |     |     | ns    |
| $t_{H(A)}$                                   | Address to CP (HIGH) Hold Time   |   | -15 |     |     |     |     | ns    |
| $t_{PHL}(CP)$<br>$t_{PLH}(CP)$               | Delay from CP (HIGH) to Output (HIGH or LOW)                             |   | 15  |     |     |     |     | ns    |
| $t_{WH}(CP)$<br>$t_{WL}(CP)$                 | CP Width (HIGH or LOW)   |   | 10  |     |     |     |     | ns    |
| $t_{S(\bar{E}_2)}$                           | $\bar{E}_2$ to CP (HIGH) Setup Time                                      |   | 10  |     |     |     |     | ns    |
| $t_{H(\bar{E}_2)}$                           | $\bar{E}_2$ to CP (HIGH) Hold Time                                       |   | 10  |     |     |     |     | ns    |
| $t_{PLH}(\bar{PS})$                          | Delay from $\bar{PS}$ (LOW) to Output (HIGH)                             |   | 17  |     |     |     |     | ns    |
| $t_{PHL}(\bar{CLR})$                         | Delay from $\bar{CLR}$ (LOW) to Output (LOW)                             |   | 17  |     |     |     |     | ns    |
| $t_{WL}(\bar{PS})$                           | PRESET Pulse Width (LOW)   |   | 10  |     |     |     |     | ns    |
| $t_{WL}(\bar{CLR})$                          | CLEAR Pulse Width (LOW)  |   | 10  |     |     |     |     | ns    |
| $t_{S}(\bar{PS})$                            | $\bar{PS}$ Recovery (Inactive) to Clock (HIGH)                           | $C_L = 5\text{pF}$ (Note 1)<br>$S_1$ closed for $t_{PLZ}$<br>and open for $t_{PHZ}$ | 12  |     |     |     |     | ns    |
| $t_{S}(\bar{CLR})$                           | $\bar{CLR}$ Recovery (Inactive) to Clock (HIGH)                          |   | 12  |     |     |     |     | ns    |
| $t_{PZL}(CP)$<br>$t_{PZH}(CP)$               | Delay from CP (HIGH) to Active Output (HIGH or LOW)                      |   | 22  |     |     |     |     | ns    |
| $t_{PZL}(\bar{E}_1)$<br>$t_{PZH}(\bar{E}_1)$ | Delay from $\bar{E}_1$ (LOW) to Active Output (HIGH or LOW)              |   | 22  |     |     |     |     | ns    |
| $t_{PLZ}(CP)$<br>$t_{PHZ}(CP)$               | Delay from CP (HIGH) to Inactive Output (OFF or high Impedance)          |   | 22  |     |     |     |     | ns    |
| $t_{PLZ}(\bar{E}_1)$<br>$t_{PHZ}(\bar{E}_1)$ | Delay from $\bar{E}_1$ (HIGH) to Inactive Output (OFF or high Impedance) |   | 22  |     |     |     |     | ns    |

Notes: 1.  $t_{PHZ}$  and  $t_{PLZ}$  are measured to the  $V_{OH} - 0.5\text{V}$  and  $V_{OL} + 0.5\text{V}$  output levels respectively. All other switching parameters are tested from and to the 1.5V threshold levels.

2. Tests are performed with input 10 to 90% rise and fall times of 5ns or less.



## PROGRAMMING

The Am27S25 is manufactured with a conductive Platinum-Silicide link at each bit location. The output of the memory with the link in place is LOW. The fusible links are opened one at a time by passing current through them from a 20 volt supply which is applied to the memory output after the  $\bar{E}_1$  input is at a logic HIGH. Current is gated through the addressed fuse by raising the  $\bar{E}_1$  input from a logic HIGH to 15 volts. After 50  $\mu$ sec, the 20 volt supply is removed, the chip is enabled and the CP input is clocked. Each data verification attempt must be preceded by a positive going (LOW-to-HIGH) clock edge to load the array data into the on-chip register. The output level is then sensed to determine if the link has opened. Most links will open within 50  $\mu$ sec. Occasionally a link will be stronger and require additional programming cycles. The recommended duration of additional programming periods is 5 msec. If a link has not opened after a total elapsed programming time of 400 msec, further programming of the device should not be attempted. Successive links are programmed in the same manner until all desired bit locations have been programmed to the HIGH level.

Typical current into an output during programming will be approximately 140mA until the fuse link is opened, after which the

current drops to approximately 40mA. Current into the  $\bar{E}_1$  pin when it is raised to 15 volts is typically 1.5mA.

The memories may become hot during programming due to the large currents being passed. Programming cycles should not be continuously applied to one device more than 5 seconds to avoid heat damage. If this programming time is exceeded, all power to the chip including  $V_{CC}$  should be removed for a period of 5 seconds after which programming may be resumed.

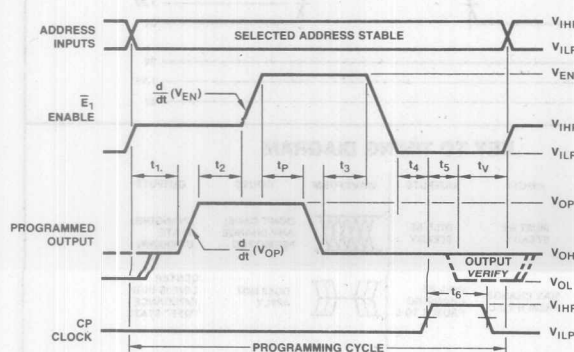
When all programming has been completed, the data content of the memory should be verified by clocking and reading all words. Occasionally this verification will show that an extra undesired link has been fused. Should this occur, immediately check the programming equipment to make sure that all device pins are firmly contacting the programming socket, that the input signal levels exhibit sufficient noise margins, and that the programming voltages are within the specified limits. All of these conditions must be maintained during programming. AMD PROMs are thoroughly tested to minimize unwanted fusing; fusing extra bits is generally related to programming equipment problems.

## PROGRAMMING PARAMETERS

| Parameter      | Description                               | Min  | Max             | Units        |
|----------------|---|------|-----------------|--------------|
| $V_{CCP}$      | $V_{CC}$ During Programming               | 5.0  | 5.5             | V            |
| $V_{IHP}$      | Input HIGH Level During Programming       | 2.4  | 5.5             | V            |
| $V_{ILP}$      | Input LOW Level During Programming        | 0.0  | 0.45            | V            |
| $V_{ENP}$      | $\bar{E}_1$ Voltage During Programming    | 14.5 | 15.5            | V            |
| $V_{OP}$       | Output Voltage During Programming         | 19.5 | 20.5            | V            |
| $V_{ONP}$      | Voltage on Outputs Not to be Programmed   | 0    | $V_{CCP} + 0.3$ | V            |
| $I_{ONP}$      | Current into Outputs Not to be Programmed |      | 20              | mA           |
| $d(V_{OP})/dt$ | Rate of Output Voltage Change             | 20   | 250             | V/ $\mu$ sec |
| $d(V_{EN})/dt$ | Rate of $\bar{E}_1$ Voltage Change        | 100  | 1000            | V/ $\mu$ sec |
| $t_p$          | Programming Period – First Attempt        | 50   | 100             | $\mu$ sec    |
|                | Programming Period – Subsequent Attempts  | 5.0  | 15              | msec         |

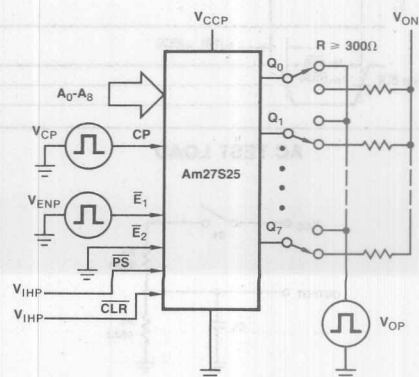
- Notes: 1. All delays between edges are specified from completion of the first edge to beginning of the second edge; i.e., not to the midpoints.  
 2. Delays  $t_1$  through  $t_6$  must be greater than 100 ns; maximum delays of 1  $\mu$ sec are recommended to minimize heating during programming.  
 3. During  $t_p$ , a user defined period, the output being programmed is switched to the load R and read to determine if additional pulses are required.  
 4. Outputs not being programmed are connected to  $V_{ONP}$  through resistor R which provides output current limiting.  
 5.  $\bar{PS}$  and  $\bar{CLR}$  must be connected to  $V_{IHP}$  during programming.

## PROGRAMMING WAVEFORMS



BPM-076

## SIMPLIFIED PROGRAMMING DIAGRAM



BPM-077







### APPLYING THE Am27S25 IN BIPOLAR MICROCOMPUTERS

With the advent of the Am2901 and Am2903 4-bit microprocessor slices, the Am2910 bipolar microprogram sequencer and the Am27S25 registered PROM, the design engineer can upgrade the performance of existing systems or implement new system taking advantage of the latest state-of-the-art technology in Low-Power Schottky integrated circuits. These devices, however, utilize a new concept in machine design not familiar to many design engineers. This technique is called microprogramming.

Basically, a microprogrammed machine is one in which a coherent sequence of microinstructions is used to execute various commands required by the machine. If the machine is a computer, each sequence of microinstructions can be made to execute a machine instruction. All of the little elemental tasks performed by the machine in executing the machine instruction are called microinstructions. The storage area for these microinstructions is usually called the microprogram memory.

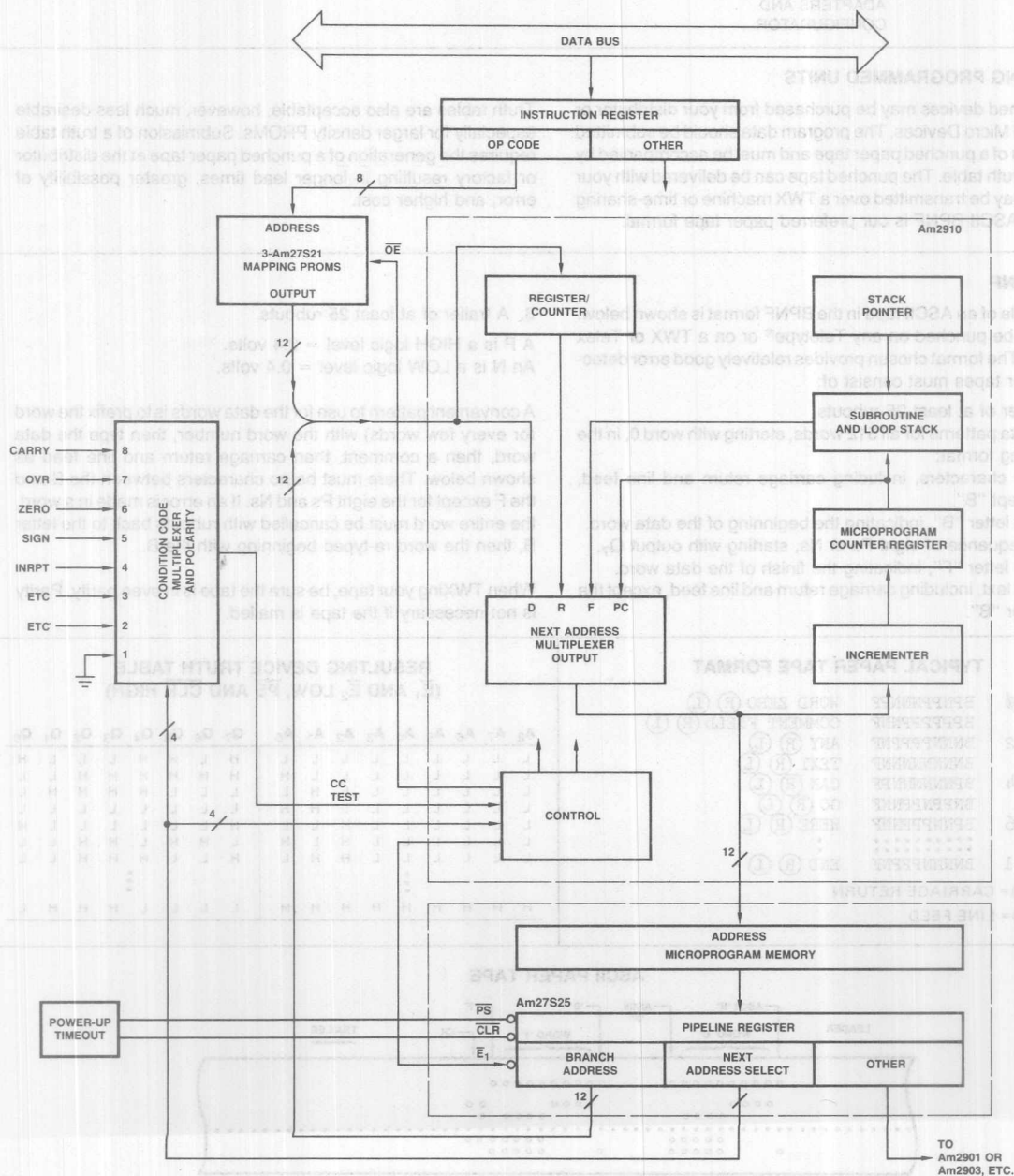


Figure 1. A Typical Computer Control Unit Using the Am27S25.

## APPLYING THE Am27S25 IN BIPOLAR MICROCOMPUTERS (Cont.)

A microinstruction usually has two primary parts. These are: (1) the definition and control of all elemental micro-operations to be carried out and (2) the definition and control of the address of the next microinstruction to be executed.

The definition of the various micro-operations to be carried out usually includes such things as ALU source operand selection, ALU function, ALU destination, carry control, shift control, interrupt control, data-in and data-out control, and so forth. The definition of the next microinstruction function usually includes identifying the source selection of the next microinstruction address and, in some cases, supplying the actual value of that microinstruction address.

Microprogrammed machines are usually distinguished from non-microprogrammed machines in the following manner. Older, non-microprogrammed machines implemented the control function by using combinations of gates and flip-flops connected in a somewhat random fashion in order to generate the required timing and control signals for the machine. Microprogrammed machines, on the other hand, are normally considered highly ordered, particularly with regard to the control function field, and use high speed PROM's for control definition. In its simplest definition, a microprogram control unit consists of the microprogram memory and the structure required to determine the address of the next microinstruction.

The microprogram memory control unit block diagram of Figure 1 is easily implemented using the Am2910 and the Am27S25 registered PROMs. This architecture provides a structured state machine design capable of executing many highly sophisticated next address control instructions. The Am2910 contains a next address multiplexer that provides four different inputs from which the address of the next microinstruction can be selected. These are the direct input (D), the register input (R), the program counter (PC), and file (F). The starting address decoder (mapping PROM) output and the Am27S25's pipeline register output are connected together at the D input to the Am2910 and are operated in the three-state mode.

The architecture of Figure 1 shows an instruction register capable of being loaded with a machine instruction word from the data bus. The op code portion of the instruction is decoded using a mapping PROM to arrive at a starting address for the microinstruction sequence required to execute the machine instruction. When the microprogram memory address is to be the first microinstruction of the machine instruction sequence, the Am2910 next address control selects the multiplexer D input and enables the three-state output from the mapping PROM. When the current microinstruction being executed is selecting the next microinstruction address as a JUMP function, the JUMP address will be available at the multiplexer D input. This is accomplished by having the Am2910 select the next address multiplexer D input and also enabling the three-state output of the pipeline register branch address field. The register enable input to the Am2910 can be grounded so that this register will load the value at the Am2910 D input. The value at D is clocked into the Am2910's register (R) at the end of the current microcycle, which makes the D value of this microcycle available as the R value of the next microcycle. Thus, by using the branch address field of two sequential microinstructions, a conditional JUMP-TO-ONE-OF-TWO-SUBROUTINES or a conditional JUMP-TO-ONE-OF-TWO-BRANCH-ADDRESSES can be executed by either selecting the D input or the R input of the next address multiplexer.

When sequencing through continuous microinstructions in the Am27S25 microprogram memory, the program counter in the

Am2910 is used. Here, the control logic simply selects the PC input of the next address multiplexer. In addition, most of these instructions enable the three-state outputs of the Am27S25 pipeline register associated with the branch address field, which allows the register within the Am2910 to be loaded. The 5 x 12 stack in the Am2910 is used for looping and subroutines in microprogram operations. Up to five levels of subroutines or loops can be nested. Also, loops and subroutines can be intermixed as long as the five word depth of the stack is not exceeded.

The Am27S25 contains a PRESET (PS) and a CLEAR (CLR) function that is useful for power-up operations and other initialization functions. These signals can also be used to provide "trap" jumps to the all zeros or ones addresses in microprogram memory.

The expansion scheme for increasing the depth of Am27S25 is shown in Figure 2. Note that no speed degradation results when devices are cascaded. This is because the decode of the Am74S139 is in parallel with the PROM access time.

In order to provide an overall view of a typical Am2900 Bipolar Microprocessor, the block diagram of Figure 3 is presented. Here, the computer control unit (CCU) using the Am2910 and Am27S25 registered PROMs is depicted. In addition, the typical connection scheme for the Am2903 Bipolar Microprocessor slices is shown. The four Am2903 devices in the block diagram form a typical 16-bit architecture. Also shown in Figure 3 is the general connection for the Am2914 Priority Interrupt Controller and the Am2920 as a Memory Address Register.

The block diagram also shows the Am2917 as the bus interface unit. Note that the Am2917 can interface directly with a data bus and the drive levels and receive levels are such that the instruction register can be built using standard Low-Power Schottky devices. This is possible because the receiver threshold on the Am2917 is designed identically to the thresholds on standard power Schottky and the Low-Power Schottky devices.

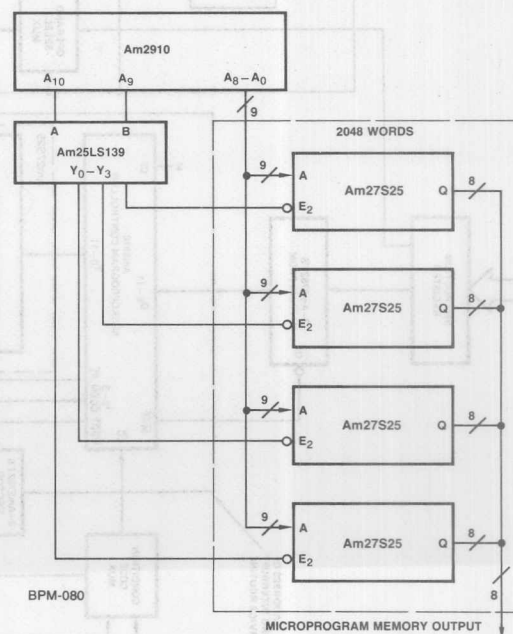


Figure 2. Word Expansion Scheme for the Am27S25.

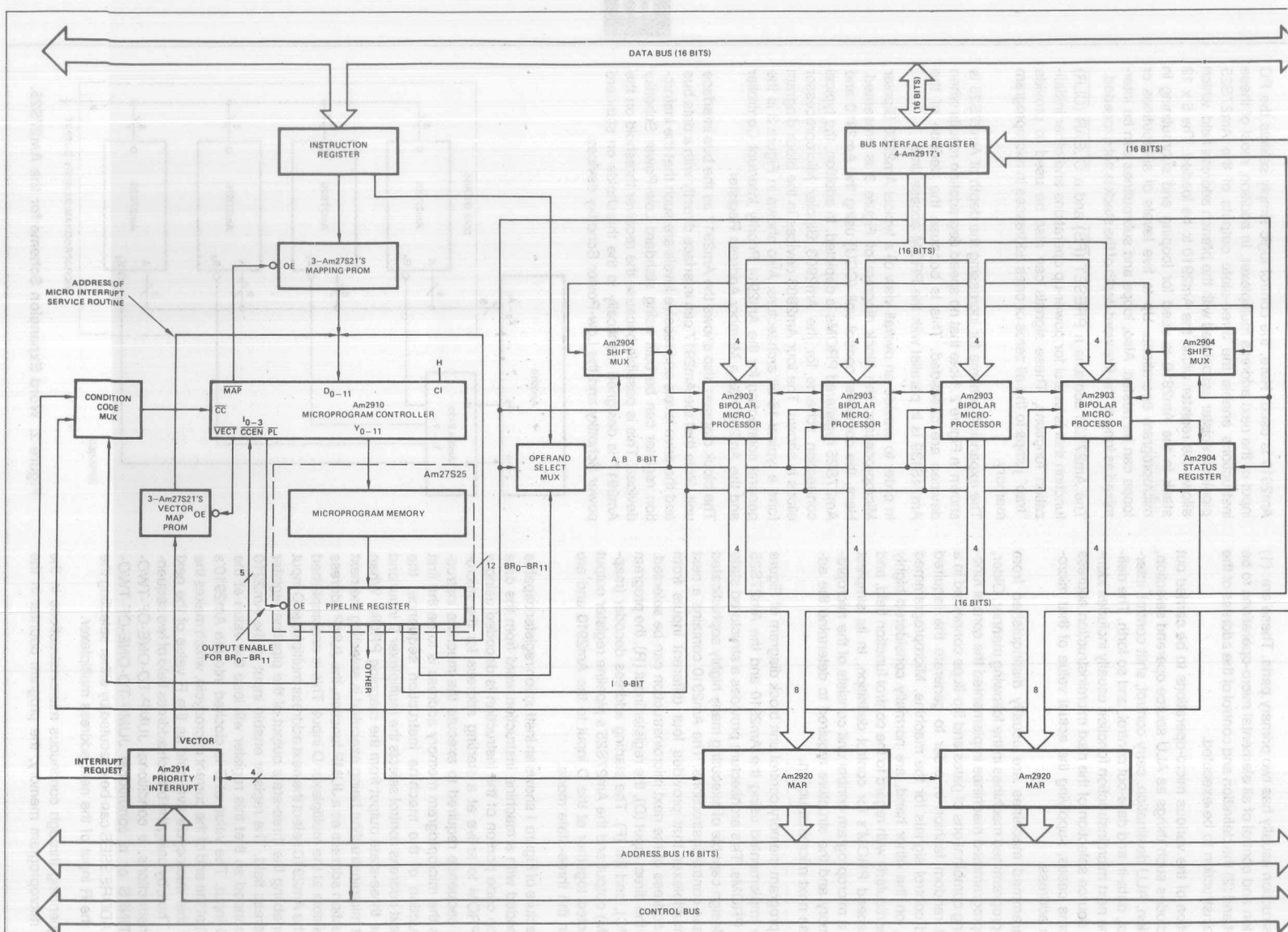
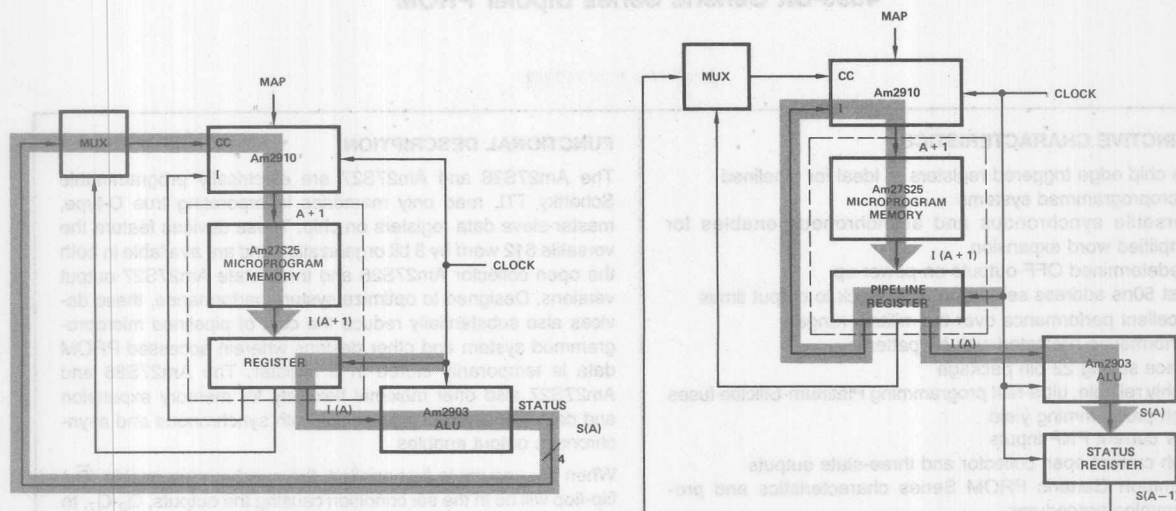


Figure 3. Typical Bipolar Microcomputer Using the Am27S25.

## USING THE Am27S25 IN A PIPELINED ARCHITECTURE



A Register at the Microprogram Memory output contains the microinstruction being executed. The microprogram memory and Am2903 delay are in series. Conditional branches are executed on same cycle as the ALU operation generating the condition.

One level pipeline provides better speed than the architecture to the left. The Microprogram Memory and the Am2903 array are in parallel speed paths instead of in series. This is the recommended architecture for Am2900 designs. Note that the Am27S25 reduces the parts count of the microprogram memory/pipeline by a factor of two.

BPM-082

5

CONNECTION DIAGRAM  
Top View

LOGIC SYMBOL





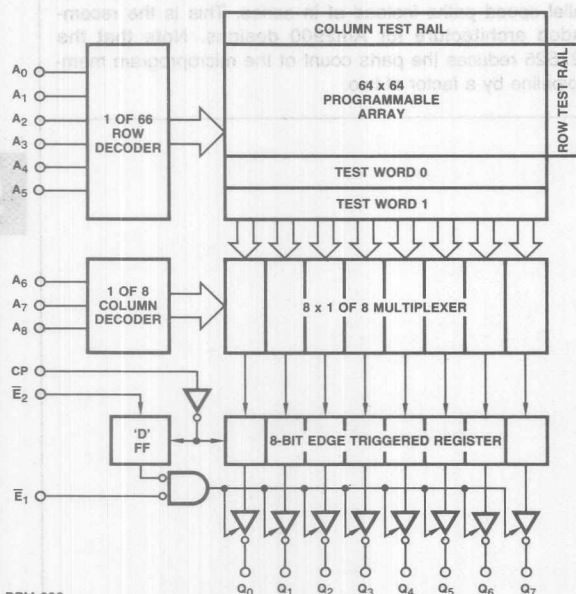
# Am27S26 • Am27S27

4096-Bit Generic Series Bipolar PROM

## DISTINCTIVE CHARACTERISTICS

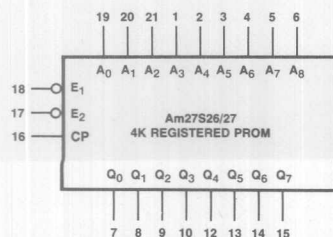
- On chip edge triggered registers – Ideal for pipelined microprogrammed systems
- Versatile synchronous and asynchronous enables for simplified word expansion
- Predetermined OFF outputs on power-up
- Fast 50ns address setup and 20ns clock to output times
- Excellent performance over the military range
- Performance pretested with  $N^2$  patterns
- Space saving 22 pin package
- Highly reliable, ultra-fast programming Platinum-Silicide fuses
- High programming yield
- Low current PNP inputs
- High current open collector and three-state outputs
- Common Generic PROM Series characteristics and programming procedures

## BLOCK DIAGRAM



BPM-036

## LOGIC SYMBOL



$V_{CC}$  = Pin 22  
GND = Pin 11

BPM-037

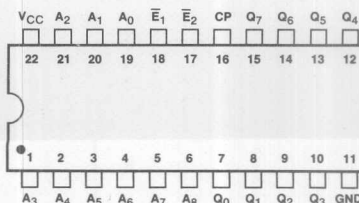
## FUNCTIONAL DESCRIPTION

The Am27S26 and Am27S27 are electrically programmable Schottky TTL read only memories incorporating true D-type, master-slave data registers on chip. These devices feature the versatile 512 word by 8 bit organization and are available in both the open collector Am27S26 and three-state Am27S27 output versions. Designed to optimize system performance, these devices also substantially reduce the cost of pipelined microprogrammed system and other designs wherein accessed PROM data is temporarily stored in a register. The Am27S26 and Am27S27 also offer maximal flexibility for memory expansion and data bus control by providing both synchronous and asynchronous output enables.

When  $V_{CC}$  power is first applied, the synchronous enable ( $\bar{E}_2$ ) flip-flop will be in the set condition causing the outputs,  $Q_0$ - $Q_7$ , to be in the OFF or high impedance state, eliminating the need for a register clear input. Reading data is accomplished by first applying the binary word address to the address inputs,  $A_0$ - $A_8$ , and a logic LOW to the synchronous output enable,  $\bar{E}_2$ . During the address setup time, stored data is accessed and loaded into the master flip-flops of the data register. Since the synchronous enable setup time is less than the address setup requirement, additional decoding delays may occur in the enable path without reducing memory performance. Upon the next LOW-to-HIGH transition of the clock, CP, data is transferred to the slave flip-flops which drive the output buffers. Providing the asynchronous enable,  $\bar{E}_1$ , is also LOW, stored data will appear on the outputs,  $Q_0$ - $Q_7$ . If  $\bar{E}_2$  is HIGH when the positive clock edge occurs, outputs go to the OFF or high impedance state. The outputs may be disabled at any time by switching  $\bar{E}_1$  to a HIGH level. Following the positive clock edge, the address and synchronous enable inputs are free to change; changes do not affect the outputs until another positive clock edge occurs. This unique feature allows the PROM decoders and sense amplifiers to access the next location while previously addressed data remains stable on the outputs. For less complex applications either enable may be effectively eliminated by tying it to ground.

The on-chip, edge triggered register simplifies system timing since the PROM clock may be derived directly from system clock without introducing dangerous race conditions. Other register timing requirements are similar to those of standard Schottky registers and are easily implemented.

## CONNECTION DIAGRAM Top View



Note: Pin 1 is marked for orientation.

BPM-038



**GENERIC SERIES CHARACTERISTICS**

The Am27S26 and Am27S27 are members of an Advanced PROM series incorporating common electrical characteristics and programming procedures. All parts in this series are produced with a fusible link at each memory location storing a logic LOW and can be selectively programmed to a logic HIGH by applying appropriate voltages to the circuit.

All parts are fabricated with AMD's fast programming highly reliable Platinum-Silicide Fuse technology. Utilizing easily implemented programming (and common programming personality card sets) these products can be rapidly programmed to any customized pattern. Extra test words are pre-programmed during manufacturing to insure extremely high field programming yields, and produce excellent parametric correlation.

Platinum-Silicide was selected as the fuse link material to achieve a well controlled melt rate resulting in large non-conductive gaps that ensure very stable long term reliability. Extensive operating testing has proven that this low-field, large-gap technology offers the best reliability for fusible link PROMs.

Common design features include active loading of all critical AC paths regulated by a built-in temperature and voltage compensated bias network to provide excellent parametric performance over MIL supply and temperature ranges. Selective feedback techniques have been employed to minimize delays through all critical paths producing the fastest speeds possible from Schottky processed PROMs.

**MAXIMUM RATINGS** (Above which the useful life may be impaired)

|  |                                |
|--|--------------------------------|
| Storage Temperature  | -65°C to +150°C                |
| Temperature (Ambient) Under Bias   | -55°C to +125°C                |
| Supply Voltage to Ground Potential (Pin 16 to Pin 8) Continuous          | -0.5V to +7.0V                 |
| DC Voltage Applied to Outputs (Except During Programming)                | -0.5V to +V <sub>CC</sub> max. |
| DC Voltage Applied to Outputs During Programming                         | 21V                            |
| Output Current into Outputs During Programming (Max. Duration of 1 sec.) | 200mA                          |
| DC Input Voltage   | -0.5V to +5.5V                 |
| DC Input Current   | -30mA to +5mA                  |

**OPERATING RANGE**

|       |                      |                                  |                             |
|-------|----------------------|----------------------------------|-----------------------------|
| COM'L | AM27S26XC, AM27S27XC | T <sub>A</sub> = 0°C to +75°C    | V <sub>CC</sub> = 5.0V ±5%  |
| MIL   | AM27S26XM, AM27S27XM | T <sub>C</sub> = -55°C to +125°C | V <sub>CC</sub> = 5.0V ±10% |

**ELECTRICAL CHARACTERISTICS OVER OPERATING RANGE** (Unless Otherwise Noted)  
**PRELIMINARY DATA**

| Parameters                        | Description                  | Test Conditions  | Min. | Typ.<br>(Note 1) | Max.   | Units |
|-----------------------------------|------------------------------|--|------|------------------|--------|-------|
| V <sub>OH</sub><br>(Am27S27 only) | Output HIGH Voltage          | V <sub>CC</sub> = MIN., I <sub>OH</sub> = -2.0mA<br>V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub> | 2.4  |                  |        | Volts |
| V <sub>OL</sub>                   | Output LOW Voltage           | V <sub>CC</sub> = MIN., I <sub>OL</sub> = 16mA<br>V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>   |      | 0.38             | 0.50   | Volts |
| V <sub>IH</sub>                   | Input HIGH Level             | Guaranteed input logical HIGH voltage for all inputs   | 2.0  |                  |        | Volts |
| V <sub>IL</sub>                   | Input LOW Level              | Guaranteed input logical LOW voltage for all inputs  |      |                  | 0.8    | Volts |
| I <sub>IL</sub>                   | Input LOW Current            | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 0.45V  |      | -0.010           | -0.250 | mA    |
| I <sub>IH</sub>                   | Input HIGH Current           | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 2.7V   |      |                  | 25     | μA    |
| I <sub>I</sub>                    | Input HIGH Current           | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 5.5V   |      |                  | 1.0    | mA    |
| I <sub>SC</sub><br>(Am27S27 only) | Output Short Circuit Current | V <sub>CC</sub> = MAX., V <sub>OUT</sub> = 0.0V (Note 2)   | -20  | -40              | -90    | mA    |
| I <sub>CC</sub>                   | Power Supply Current         | All inputs = GND<br>V <sub>CC</sub> = MAX.   |      | 130              | 185    | mA    |
| V <sub>I</sub>                    | Input Clamp Voltage          | V <sub>CC</sub> = MIN., I <sub>IN</sub> = -18mA  |      |                  | -1.2   | Volts |
| I <sub>CEX</sub>                  | Output Leakage Current       | V <sub>CC</sub> = MAX.<br>V <sub>E1</sub> = 2.4V   |      |                  | 100    | μA    |
|                                   |                              | Am27S27 Only   |      |                  | 40     |       |
|                                   |                              |  |      |                  | -40    |       |
| C <sub>IN</sub>                   | Input Capacitance            | V <sub>IN</sub> = 2.0V @ f = 1MHz (Note 3)   |      | 5                |        | pF    |
| C <sub>OUT</sub>                  | Output Capacitance           | V <sub>OUT</sub> = 2.0V @ f = 1MHz (Note 3)  |      | 12               |        |       |

Notes: 1. Typical limits are at V<sub>CC</sub> = 5.0V and T<sub>A</sub> = 25°C.

2. Not more than one output should be shorted at a time. Duration of the short circuit should not be more than one second.

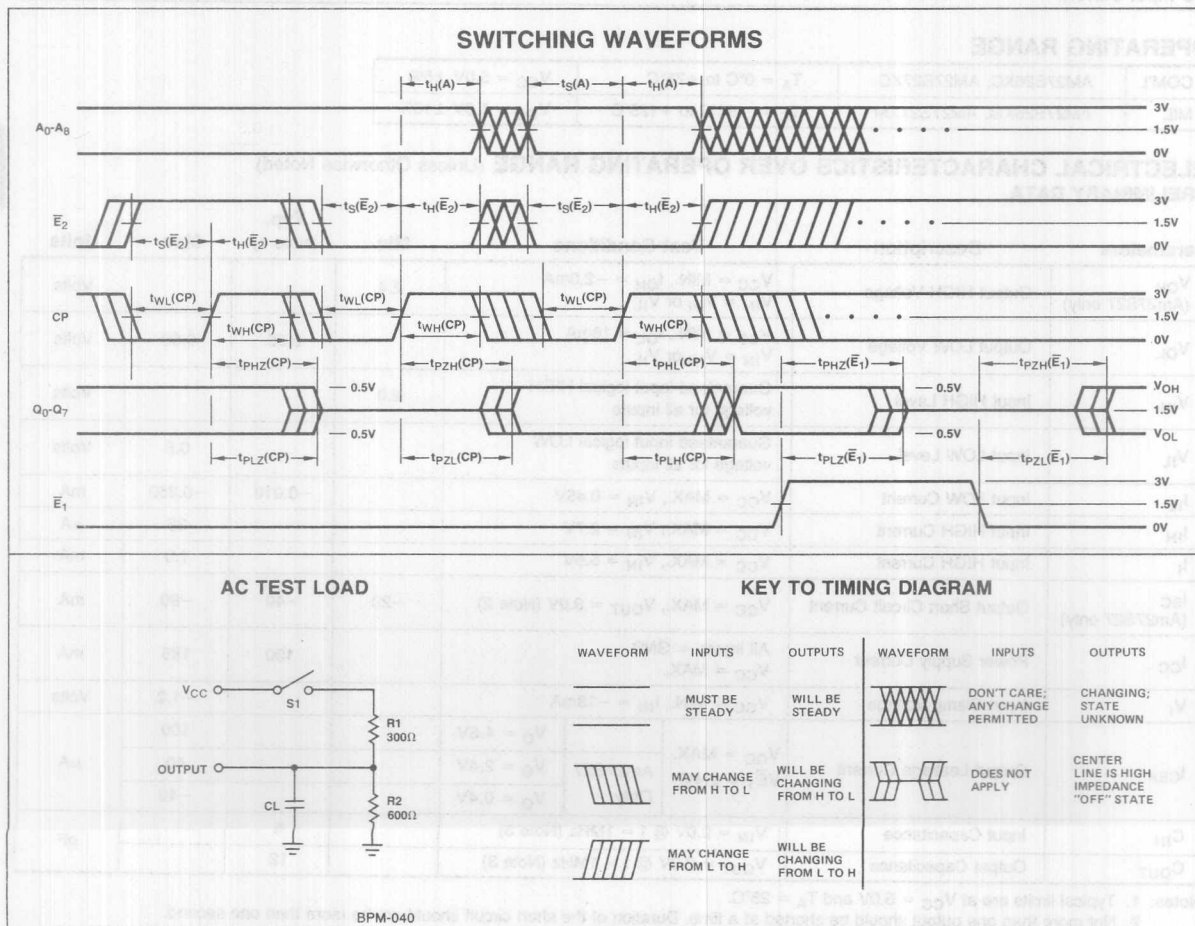
3. These parameters are not 100% tested, but are periodically sampled.

|  |  |   | Typ<br>5V | COM'L |     | MIL |     |       |
|--|--|---|-----------|-------|-----|-----|-----|-------|
| Parameter  | Description  | Test Conditions   | 25°C      | Min   | Max | Min | Max | Units |
| t <sub>S</sub> (A)   | Address to CP (HIGH) Setup Time  | C <sub>L</sub> = 30pF<br>S <sub>1</sub> closed.<br>(See AC Test Load below)                               | 40        | 55    |     | 65  |     | ns    |
| t <sub>H</sub> (A)   | Address to CP (HIGH) Hold Time   |   | −15       | 0     |     | 0   |     | ns    |
| t <sub>PHL</sub> (CP)<br>t <sub>PLH</sub> (CP)                           | Delay from CP (HIGH) to Output (HIGH or LOW)   |   | 15        |       | 27  |     | 30  | ns    |
| t <sub>WH</sub> (CP)<br>t <sub>WL</sub> (CP)                             | CP Width (HIGH or LOW)   |   | 10        |       | 30  |     | 40  | ns    |
| t <sub>S</sub> (E <sub>2</sub> )   | E <sub>2</sub> to CP (HIGH) Setup Time   |   | 10        | 25    |     | 30  |     | ns    |
| t <sub>H</sub> (E <sub>2</sub> )   | E <sub>2</sub> to CP (HIGH) Hold Time  |   | −10       | 0     |     | 0   |     | ns    |
| t <sub>PZL</sub> (CP)<br>t <sub>PZH</sub> (CP)                           | Delay from CP (HIGH) to Active Output (HIGH or LOW) (Note 1)                         | C <sub>L</sub> = 30pF<br>S <sub>1</sub> closed for t <sub>PZL</sub> and open for t <sub>PZH</sub>         | 15        |       | 35  |     | 45  | ns    |
| t <sub>PZL</sub> (E <sub>1</sub> )<br>t <sub>PZH</sub> (E <sub>1</sub> ) | Delay from E <sub>1</sub> (LOW) to Active Output (HIGH or LOW) (Note 1)              |   | 15        |       | 40  |     | 45  | ns    |
| t <sub>PLZ</sub> (CP)<br>t <sub>PHZ</sub> (CP)                           | Delay from CP (HIGH) to Inactive Output (OFF or high Impedance) (Note 1)             | C <sub>L</sub> = 5pF (Note 2)<br>S <sub>1</sub> closed for t <sub>PLZ</sub> and open for t <sub>PHZ</sub> | 15        |       | 35  |     | 45  | ns    |
| t <sub>PLZ</sub> (E <sub>1</sub> )<br>t <sub>PHZ</sub> (E <sub>1</sub> ) | Delay from E <sub>1</sub> (HIGH) to Inactive Output (OFF or high Impedance) (Note 1) |   | 10        |       | 30  |     | 40  | ns    |

Notes: 1.  $t_{PHZ}$  and  $t_{PZH}$  apply to the three-state Am27S27 only.

2.  $t_{PHZ}$  and  $t_{PLZ}$  are measured to the  $V_{OH} - 0.5\text{V}$  and  $V_{OL} + 0.5\text{V}$  output levels respectively. All other switching parameters are tested from and to the 1.5V threshold levels.

3. Tests are performed with input 10 to 90% rise and fall times of 5ns or less.



## PROGRAMMING

The Am27S26 and Am27S27 are manufactured with a conductive Platinum-Silicide link at each bit location. The output of the memory with the link in place is LOW. The fusible links are opened one at a time by passing current through them from a 20 volt supply which is applied to the memory output after the  $\bar{E}_1$  input is at a logic HIGH. Current is gated through the addressed fuse by raising the  $\bar{E}_1$  input from a logic HIGH to 15 volts. After 50  $\mu$ sec, the 20 volt supply is removed, the chip is enabled and the CP input is clocked. Each data verification attempt must be preceded by a positive going (LOW-to-HIGH) clock edge to load the array data into the on-chip register. The output level is then sensed to determine if the link has opened. Most links will open within 50  $\mu$ sec. Occasionally a link will be stronger and require additional programming cycles. The recommended duration of additional programming periods is 5 msec. If a link has not opened after a total elapsed programming time of 400 msec, further programming of the device should not be attempted. Successive links are programmed in the same manner until all desired bit locations have been programmed to the HIGH level.

Typical current into an output during programming will be approximately 140mA until the fuse link is opened, after which the

current drops to approximately 40mA. Current into the  $\bar{E}_1$  pin when it is raised to 15 volts is typically 1.5mA.

The memories may become hot during programming due to the large currents being passed. Programming cycles should not be continuously applied to one device more than 5 seconds to avoid heat damage. If this programming time is exceeded, all power to the chip including  $V_{CC}$  should be removed for a period of 5 seconds after which programming may be resumed.

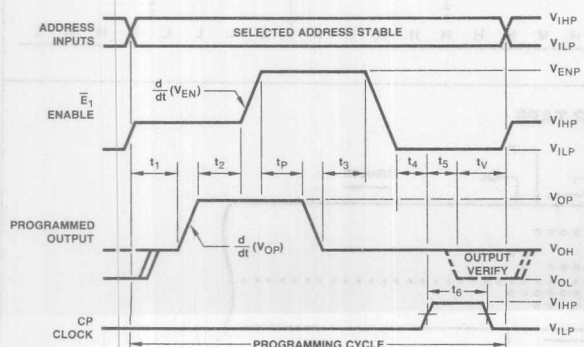
When all programming has been completed, the data content of the memory should be verified by clocking and reading all words. Occasionally this verification will show that an extra undesired link has been fused. Should this occur, immediately check the programming equipment to make sure that all device pins are firmly contacting the programming socket, that the input signal levels exhibit sufficient noise margins, and that the programming voltages are within the specified limits. All of these conditions must be maintained during programming. AMD PROMs are thoroughly tested to minimize unwanted fusing; fusing extra bits is generally related to programming equipment problems.

## PROGRAMMING PARAMETERS

| Parameter      | Description                               | Min. | Max.            | Units        |
|----------------|---|------|-----------------|--------------|
| $V_{CCP}$      | $V_{CC}$ During Programming               | 5.0  | 5.5             | V            |
| $V_{IHP}$      | Input HIGH Level During Programming       | 2.4  | 5.5             | V            |
| $V_{ILP}$      | Input LOW Level During Programming        | 0.0  | 0.45            | V            |
| $V_{ENP}$      | $\bar{E}_1$ Voltage During Programming    | 14.5 | 15.5            | V            |
| $V_{OP}$       | Output Voltage During Programming         | 19.5 | 20.5            | V            |
| $V_{ONP}$      | Voltage on Outputs Not to be Programmed   | 0    | $V_{CCP} + 0.3$ | V            |
| $I_{ONP}$      | Current into Outputs Not to be Programmed |      | 20              | mA           |
| $d(V_{OP})/dt$ | Rate of Output Voltage Change             | 20   | 250             | V/ $\mu$ sec |
| $d(V_{EN})/dt$ | Rate of $\bar{E}_1$ Voltage Change        | 100  | 1000            | V/ $\mu$ sec |
| $t_p$          | Programming Period – First Attempt        | 50   | 100             | $\mu$ sec    |
|                | Programming Period – Subsequent Attempts  | 5.0  | 15              | msec         |

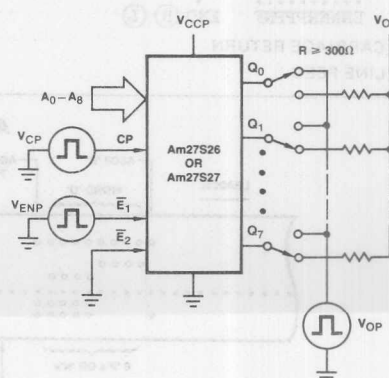
- Notes: 1. All delays between edges are specified from completion of the first edge to beginning of the second edge; i.e., not to the midpoints.  
 2. Delays  $t_1$  through  $t_6$  must be greater than 100 ns; maximum delays of 1  $\mu$ sec are recommended to minimize heating during programming.  
 3. During  $t_v$ , a user defined period, the output being programmed is switched to the load R and read to determine if additional pulses are required.  
 4. Outputs not being programmed are connected to  $V_{ONP}$  through resistor R which provides output current limiting.

## PROGRAMMING WAVEFORMS



BPM-041

## SIMPLIFIED PROGRAMMING DIAGRAM



BPM-042

## PROGRAMMING EQUIPMENT

Generic programming boards and device adapters are available from the sources listed below. In each case, the programming boards are used in these manufacturer's automatic

programmers to program all AMD generic series bipolar PROMs; individual adapters are required for each basic part type in the series.

## SOURCE AND LOCATION

## PROGRAMMER MODEL(S)

AMD GENERIC BIPOLAR  
PROM PERSONALITY BOARD

Am27S26 • Am27S27

ADAPTERS AND  
CONFIGURATOR

Data I/O Corp.  
P.O. Box 308  
Issaquah, Wash. 98027

Model 5, 7 and 9  
909-1286-1

715-1412-2

Pro-Log Corp.  
2411 Garden Road  
Monterey, Ca. 93940

M900 and M920  
PM9058

PA22-4 and 512 x 8 (L)

## OBTAINING PROGRAMMED UNITS

Programmed devices may be purchased from your distributor or Advanced Micro Devices. The program data should be submitted in the form of a punched paper tape and must be accompanied by a written truth table. The punched tape can be delivered with your order or may be transmitted over a TWX machine or time-sharing terminal. ASCII BPNF is our preferred paper tape format.

Truth tables are also acceptable, however, much less desirable especially for larger density PROMs. Submission of a truth table requires the generation of a punched paper tape at the distributor or factory resulting in longer lead times, greater possibility of error, and higher cost.

## ASCII BPNF

An example of an ASCII tape in the BPNF format is shown below. They can be punched on any Teletype® or on a TWX or Telex machine. The format chosen provides relatively good error detection. Paper tapes must consist of:

1. A leader of at least 25 rubouts.
2. The data patterns for all 512 words, starting with word 0, in the following format:
  - a. Any characters, including carriage return and line feed, except "B".
  - b. The letter "B", indicating the beginning of the data word.
  - c. A sequence of eight Ps or Ns, starting with output Q<sub>7</sub>.
  - d. The letter "F", indicating the finish of the data word.
  - e. Any text, including carriage return and line feed, except the letter "B".

3. A trailer of at least 25 rubouts.

A P is a HIGH logic level = 2.4 volts.

An N is a LOW logic level = 0.4 volts.

A convenient pattern to use for the data words is to prefix the word (or every few words) with the word number, then type the data word, then a comment, then carriage return and line feed as shown below. There must be no characters between the B and the F except for the eight Ps and Ns. If an error is made in a word, the entire word must be cancelled with rubouts back to the letter B, then the word re-typed beginning with the B.

When TWXing your tape, be sure the tape is in even parity. Parity is not necessary if the tape is mailed.

## TYPICAL PAPER TAPE FORMAT

```

0000 BPNPPNNPF WORD ZERO (R) (L)
0001 BPPPPPPNPF COMMENT FIELD (R) (L)
0002 BNNNPPPPNF ANY (R) (L)
0003 BNNNNNNNPF TEXT (R) (L)
0004 BPNNNNNNPF CAN (R) (L)
0005 BNPPNPPNPF GO (R) (L)
0006 BPNPPPPNPF HERE (R) (L)
0007 .....
5111 BNNNPPPPNF END (R) (L)
  
```

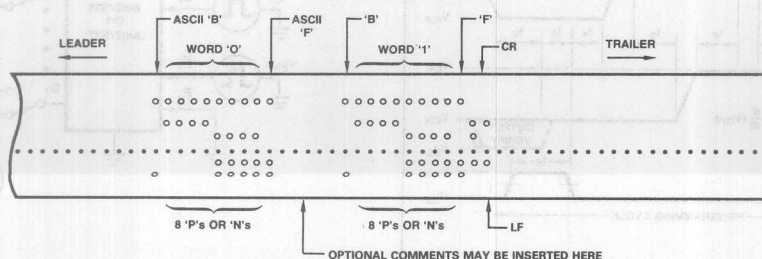
(R) = CARRIAGE RETURN

(L) = LINE FEED

RESULTING DEVICE TRUTH TABLE ( $\bar{E}_1$  AND  $\bar{E}_2$  LOW)

| A <sub>8</sub> | A <sub>7</sub> | A <sub>6</sub> | A <sub>5</sub> | A <sub>4</sub> | A <sub>3</sub> | A <sub>2</sub> | A <sub>1</sub> | A <sub>0</sub> | Q <sub>7</sub> | Q <sub>6</sub> | Q <sub>5</sub> | Q <sub>4</sub> | Q <sub>3</sub> | Q <sub>2</sub> | Q <sub>1</sub> | Q <sub>0</sub> |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| L              | L              | L              | L              | L              | L              | L              | L              | L              | H              | H              | H              | H              | H              | H              | L              | L              |
| L              | L              | L              | L              | L              | L              | L              | L              | H              | L              | L              | L              | H              | H              | H              | H              | L              |
| L              | L              | L              | L              | L              | L              | L              | H              | H              | L              | L              | L              | L              | L              | L              | L              | L              |
| L              | L              | L              | L              | L              | L              | H              | L              | L              | H              | L              | L              | L              | L              | L              | L              | H              |
| L              | L              | L              | L              | L              | H              | L              | H              | L              | L              | H              | H              | L              | H              | H              | L              | L              |
| L              | L              | L              | L              | L              | H              | H              | L              | L              | H              | L              | L              | H              | H              | H              | L              | L              |
| H              | H              | H              | H              | H              | H              | H              | H              | H              | L              | L              | L              | L              | H              | H              | H              | L              |

## ASCII PAPER TAPE

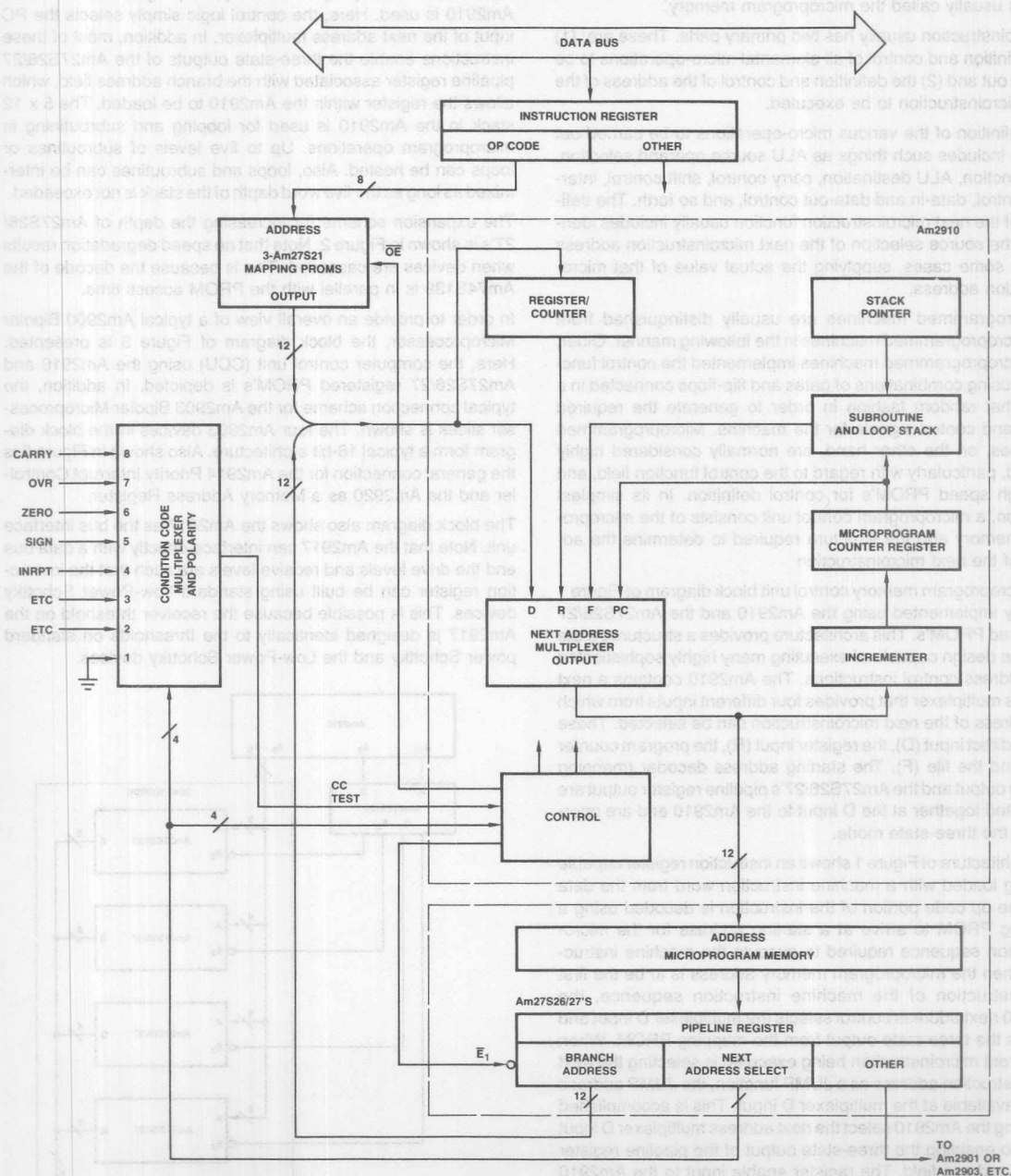


BPM-043



With the advent of the Am2901 and Am2903 4-bit microprocessor slices, the Am2910 bipolar microprogram sequencer and the Am27S26/27 registered PROM, the design engineer can upgrade the performance of existing systems or implement new systems taking advantage of the latest state-of-the-art tech-

nology in Low-Power Schottky integrated circuits. These devices, however, utilize a new concept in machine design not familiar to many design engineers. This technique is called microprogramming.



**Fig. 1. A Typical Computer Control Unit using the Am27S26/27.**



## APPLYING THE Am27S26 and Am27S27 IN BIPOLAR MICROCOMPUTERS (Cont.)

Basically, a microprogrammed machine is one in which a coherent sequence of microinstructions is used to execute various commands required by the machine. If the machine is a computer, each sequence of microinstructions can be made to execute a machine instruction. All of the little elemental tasks performed by the machine in executing the machine instruction are called microinstructions. The storage area for these microinstructions is usually called the microprogram memory.

A microinstruction usually has two primary parts. These are: (1) the definition and control of all elemental micro-operations to be carried out and (2) the definition and control of the address of the next microinstruction to be executed.

The definition of the various micro-operations to be carried out usually includes such things as ALU source operand selection, ALU function, ALU destination, carry control, shift control, interrupt control, data-in and data-out control, and so forth. The definition of the next microinstruction function usually includes identifying the source selection of the next microinstruction address and, in some cases, supplying the actual value of that microinstruction address.

Microprogrammed machines are usually distinguished from non-microprogrammed machines in the following manner. Older, non-microprogrammed machines implemented the control function by using combinations of gates and flip-flops connected in a somewhat random fashion in order to generate the required timing and control signals for the machine. Microprogrammed machines, on the other hand, are normally considered highly ordered, particularly with regard to the control function field, and use high speed PROM's for control definition. In its simplest definition, a microprogram control unit consists of the microprogram memory and the structure required to determine the address of the next microinstruction.

The microprogram memory control unit block diagram of Figure 1 is easily implemented using the Am2910 and the Am27S26/27 registered PROM's. This architecture provides a structured state machine design capable of executing many highly sophisticated next address control instructions. The Am2910 contains a next address multiplexer that provides four different inputs from which the address of the next microinstruction can be selected. These are the direct input (D), the register input (R), the program counter (PC), and the file (F). The starting address decoder (mapping PROM) output and the Am27S26/27's pipeline register output are connected together at the D input to the Am2910 and are operated in the three-state mode.

The architecture of Figure 1 shows an instruction register capable of being loaded with a machine instruction word from the data bus. The op code portion of the instruction is decoded using a mapping PROM to arrive at a starting address for the microinstruction sequence required to execute the machine instruction. When the microprogram memory address is to be the first microinstruction of the machine instruction sequence, the Am2910 next address control selects the multiplexer D input and enables the three-state output from the mapping PROM. When the current microinstruction being executed is selecting the next microinstruction address as a JUMP function, the JUMP address will be available at the multiplexer D input. This is accomplished by having the Am2910 select the next address multiplexer D input and also enabling the three-state output of the pipeline register branch address field. The register enable input to the Am2910 *can be grounded so that this register will load the value at the Am2910 D input. The value at D is clocked into the Am2910's register (R) at the end of the current microcycle, which makes the D value of this microcycle available as the R value of the next*

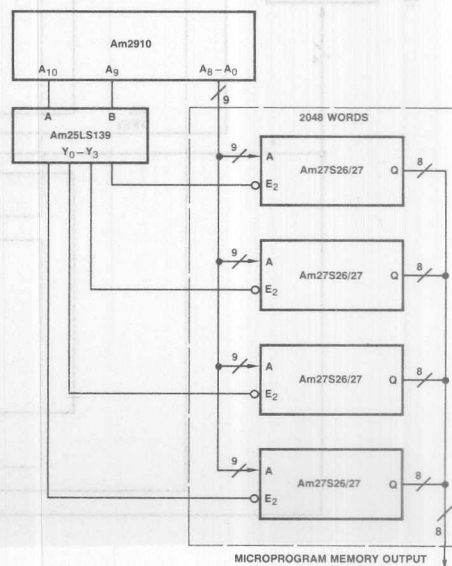
microcycle. Thus, by using the branch address field of two sequential microinstructions, a conditional JUMP-TO-ONE-OF-TWO-SUBROUTINES or a conditional JUMP-TO-ONE-OF-TWO-BRANCH-ADDRESSES can be executed by either selecting the D input or the R input of the next address multiplexer.

When sequencing through continuous microinstructions in the Am27S26/27 microprogram memory, the program counter in the Am2910 is used. Here, the control logic simply selects the PC input of the next address multiplexer. In addition, most of these instructions enable the three-state outputs of the Am27S26/27 pipeline register associated with the branch address field, which allows the register within the Am2910 to be loaded. The 5 x 12 stack in the Am2910 is used for looping and subroutines in microprogram operations. Up to five levels of subroutines or loops can be nested. Also, loops and subroutines can be intermixed as long as the five word depth of the stack is not exceeded.

The expansion scheme for increasing the depth of Am27S26/27's is shown in Figure 2. Note that no speed degradation results when devices are cascaded. This is because the decode of the Am74S139 is in parallel with the PROM access time.

In order to provide an overall view of a typical Am2900 Bipolar Microprocessor, the block diagram of Figure 3 is presented. Here, the computer control unit (CCU) using the Am2910 and Am27S26/27 registered PROM's is depicted. In addition, the typical connection scheme for the Am2903 Bipolar Microprocessor slices is shown. The four Am2903 devices in the block diagram form a typical 16-bit architecture. Also shown in Figure 3 is the general connection for the Am2914 Priority Interrupt Controller and the Am2920 as a Memory Address Register.

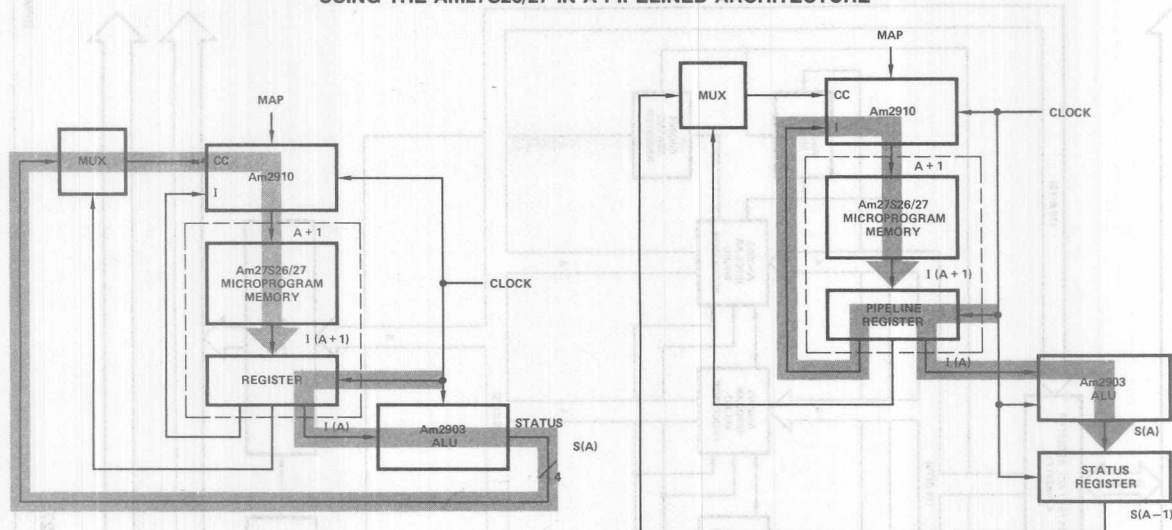
The block diagram also shows the Am2917 as the bus interface unit. Note that the Am2917 can interface directly with a data bus and the drive levels and receive levels are such that the instruction register can be built using standard Low-Power Schottky devices. This is possible because the receiver threshold on the Am2917 is designed identically to the thresholds on standard power Schottky and the Low-Power Schottky devices.



**Fig. 2. Word Expansion Scheme for the Am27S26 and Am27S27.**



## USING THE Am27S26/27 IN A PIPELINED ARCHITECTURE



A Register at the Microprogram Memory output contains the microinstruction being executed. The microprogram memory and Am2903 delay are in series. Conditional branches are executed on same cycle as the ALU operation generating the condition.

One level pipeline provides better speed than the architecture to the left. The Microprogram Memory and the Am2903 array are in parallel speed paths instead of in series. This is the recommended architecture for Am2900 designs. Note that the Am27S26/27 reduces the parts count of the microprogram memory/pipeline by a factor of two.

BPM-047

BPM-048

## ORDERING INFORMATION

| Package Type        | Temperature Range | Order Number |
|---------------------|-------------------|--------------|
| Open Collectors     |                   |              |
| Hermetic DIP        | 0°C to +75°C      | AM27S26DC    |
| Hermetic DIP        | -55°C to +125°C   | AM27S26DM    |
| Three-State Outputs |                   |              |
| Hermetic DIP        | 0°C to +75°C      | AM27S27DC    |
| Hermetic DIP        | -55°C to +125°C   | AM27S27DM    |

# Am27S28 • Am27S29

4096-Bit Generic Series Bipolar PROM

## DISTINCTIVE CHARACTERISTICS

- High Speed — 55ns max commercial range access time
- Excellent performance over full MIL and commercial ranges
- Highly reliable, ultra-fast programming Platinum-Silicide fuses
- High programming yield
- Low current PNP inputs
- High current open collector and three-state outputs
- Fast chip select
- Access time tested with N<sup>2</sup> patterns
- Pin for pin replacements for industry standard products
- Common Generic PROM series electrical characteristics and simple programming procedures.

## GENERIC SERIES CHARACTERISTICS

The Am27S28 and Am27S29 are members of an Advanced PROM series incorporating common electrical characteristics and programming procedures. All parts in this series are produced with a fusible link at each memory location storing a logic LOW and can be selectively programmed to a logic HIGH by applying appropriate voltages to the circuit.

All parts are fabricated with AMD's fast programming highly reliable Platinum-Silicide Fuse technology. Utilizing easily implemented programming (and common programming personality card sets) these products can be rapidly programmed to any customized pattern. Extra test rows are pre-programmed during manufacturing to insure extremely high field programming yields, and produce excellent parametric correlation.

Platinum-Silicide was selected as the fuse link material to achieve a well controlled melt rate resulting in large non-conductive gaps that ensure very stable long term reliability. Extensive operating testing has proven that this low-field, large-gap technology offers the best reliability for fusible link PROMs.

Common design features include active loading of all critical AC paths regulated by a built-in temperature and voltage compensated bias network to provide excellent parametric performance over MIL supply and temperature ranges. Selective feedback techniques have been employed to minimize delays through all critical paths producing the fastest speeds possible from Schottky processed PROMs.

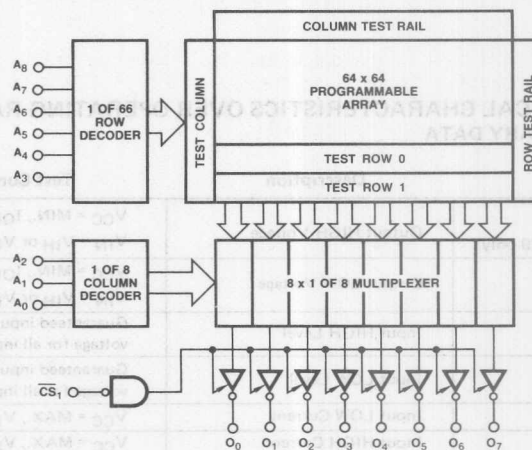
## ORDERING INFORMATION

| Package Type        | Temperature Range | Order Number |
|---------------------|-------------------|--------------|
| Open Collectors     |                   |              |
| Hermetic DIP        | 0°C to +75°C      | AM27S28DC    |
| Hermetic DIP        | -55°C to +125°C   | AM27S28DM    |
| Three-State Outputs |                   |              |
| Hermetic DIP        | 0°C to +75°C      | AM27S29DC    |
| Hermetic DIP        | -55°C to +125°C   | AM27S29DM    |

## FUNCTIONAL DESCRIPTION

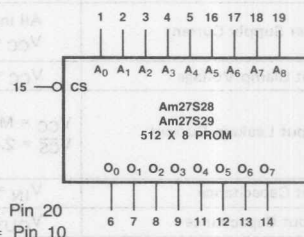
The Am27S28 and Am27S29 are high speed electrically programmable Schottky read only memories. Organized in the industry standard 512 x 8 configuration, they are available in both open collector Am27S28 and three-state Am27S29 output versions. After programming, stored information is read on outputs O<sub>0</sub>-O<sub>7</sub> by applying unique binary addresses to A<sub>0</sub>-A<sub>8</sub> and holding the chip select input,  $\overline{CS}$ , at a logic LOW. If the chip select input goes to a logic HIGH, O<sub>0</sub>-O<sub>7</sub> go to the off or high impedance state.

## BLOCK DIAGRAM



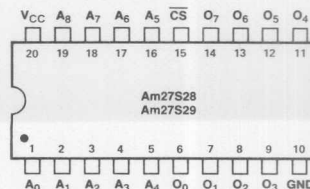
BPM-083

## LOGIC SYMBOL



BPM-084

## CONNECTION DIAGRAM Top View



Note: Pin 1 is marked for orientation.

BPM-085



## Am27S28 • Am27S29

### MAXIMUM RATINGS (Above which the useful life may be impaired)

|  |                                |
|--|--------------------------------|
| Storage Temperature  | -65°C to +150°C                |
| Temperature (Ambient) Under Bias   | -55°C to +125°C                |
| Supply Voltage to Ground Potential (Pin 20 to Pin 10) Continuous         | -0.5V to +7.0V                 |
| DC Voltage Applied to Outputs (Except During Programming)                | -0.5V to +V <sub>CC</sub> max. |
| DC Voltage Applied to Outputs During Programming                         | 21V                            |
| Output Current into Outputs During Programming (Max. Duration of 1 sec.) | 200mA                          |
| DC Input Voltage   | -0.5V to +5.5V                 |
| DC Input Current   | -30mA to +5mA                  |

### OPERATING RANGE

|       |                      |                                  |                             |
|-------|----------------------|----------------------------------|-----------------------------|
| COM'L | Am27S28XC, Am27S29XC | T <sub>A</sub> = 0°C to +75°C    | V <sub>CC</sub> = 5.0V ±5%  |
| MIL   | Am27S28XM, Am27S29XM | T <sub>A</sub> = -55°C to +125°C | V <sub>CC</sub> = 5.0V ±10% |

### ELECTRICAL CHARACTERISTICS OVER OPERATING RANGE (Unless Otherwise Noted) PRELIMINARY DATA

| Parameters                        | Description                  | Test Conditions  | Min. | Typ.<br>(Note 1) | Max.   | Units |
|-----------------------------------|------------------------------|--|------|------------------|--------|-------|
| V <sub>OH</sub><br>(Am27S29 only) | Output HIGH Voltage          | V <sub>CC</sub> = MIN., I <sub>OH</sub> = -2.0mA<br>V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub> | 2.4  |                  |        | Volts |
| V <sub>OL</sub>                   | Output LOW Voltage           | V <sub>CC</sub> = MIN., I <sub>OL</sub> = 16mA<br>V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>   |      |                  | 0.50   | Volts |
| V <sub>IH</sub>                   | Input HIGH Level             | Guaranteed input logical HIGH voltage for all inputs   | 2.0  |                  |        | Volts |
| V <sub>IL</sub>                   | Input LOW Level              | Guaranteed input logical LOW voltage for all inputs  |      |                  | 0.8    | Volts |
| I <sub>IL</sub>                   | Input LOW Current            | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 0.45V  |      | -0.010           | -0.250 | mA    |
| I <sub>IH</sub>                   | Input HIGH Current           | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 2.7V   |      |                  | 25     | μA    |
| I <sub>I</sub>                    | Input HIGH Current           | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 5.5V   |      |                  | 1.0    | mA    |
| I <sub>SC</sub><br>(Am27S29 only) | Output Short Circuit Current | V <sub>CC</sub> = MAX., V <sub>OUT</sub> = 0.0V (Note 2)   | -20  | -40              | -90    | mA    |
| I <sub>CC</sub>                   | Power Supply Current         | All inputs = GND<br>V <sub>CC</sub> = MAX.   |      | 105              | 160    | mA    |
| V <sub>I</sub>                    | Input Clamp Voltage          | V <sub>CC</sub> = MIN., I <sub>IN</sub> = -18mA  |      |                  | -1.2   | Volts |
| I <sub>CEX</sub>                  | Output Leakage Current       | V <sub>CC</sub> = MAX.<br>V <sub>CS</sub> = 2.4V   |      |                  | 40     | μA    |
|                                   |                              | Am27S29 only   |      |                  | 40     |       |
|                                   |                              |  |      |                  | -40    |       |
| C <sub>IN</sub>                   | Input Capacitance            | V <sub>IN</sub> = 2.0V @ f = 1 MHz (Note 3)  |      | 4                |        | pF    |
| C <sub>OUT</sub>                  | Output Capacitance           | V <sub>OUT</sub> = 2.0V @ f = 1 MHz (Note 3)   |      | 8                |        |       |

- Notes: 1. Typical limits are at V<sub>CC</sub> = 5.0V and T<sub>A</sub> = 25°C.  
2. Not more than one output should be shorted at a time. Duration of the short circuit should not be more than one second.  
3. These parameters are not 100% tested, but periodically sampled.





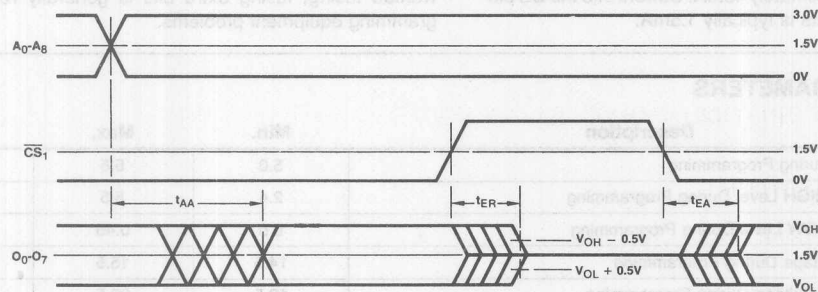
# SWITCHING CHARACTERISTICS OVER OPERATING RANGE

## PRELIMINARY DATA

| Parameter | Description          | Test Conditions                 | Typ        | Max   |     | Units |
|-----------|----------------------|---------------------------------|------------|-------|-----|-------|
|           |                      |                                 | 5V<br>25°C | COM'L | MIL |       |
| $t_{AA}$  | Address Access Time  | AC Test Load<br>(See Notes 1-3) | 35         | 55    | 70  | ns    |
| $t_{EA}$  | Enable Access Time   |                                 | 15         | 25    | 30  | ns    |
| $t_{ER}$  | Enable Recovery Time |                                 | 15         | 25    | 30  | ns    |

- Notes: 1.  $t_{AA}$  is tested with switch  $S_1$  closed and  $C_L = 30\text{pF}$ .  
 2. For open collector outputs,  $t_{EA}$  and  $t_{ER}$  are tested with  $S_1$  closed to the 1.5V output level.  $C_L = 30\text{pF}$ .  
 3. For three state outputs,  $t_{EA}$  is tested with  $C_L = 30\text{pF}$  to the 1.5V level;  $S_1$  is open for high impedance to HIGH tests and closed for high impedance to LOW tests.  $t_{ER}$  is tested with  $C_L = 5\text{pF}$ . HIGH to high impedance tests are made with  $S_1$  open to an output voltage of  $V_{OH} - 0.5\text{V}$ ; LOW to high impedance tests are made with  $S_1$  closed to the  $V_{OL} + 0.5\text{V}$  level.

### SWITCHING WAVEFORMS



Note: Level on output while  $\overline{CS}$  is HIGH is determined externally.

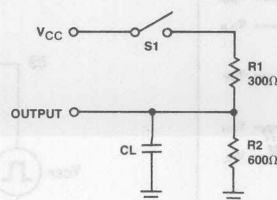
BPM-086

5

### KEY TO TIMING DIAGRAM

| WAVEFORM | INPUTS                 | OUTPUTS                      | WAVEFORM | INPUTS                           | OUTPUTS                                   |
|----------|------------------------|------------------------------|----------|----------------------------------|---|
|          | MUST BE STEADY         | WILL BE STEADY               |          | DON'T CARE; ANY CHANGE PERMITTED | CHANGING; STATE UNKNOWN                   |
|          | MAY CHANGE FROM H TO L | WILL BE CHANGING FROM H TO L |          | DOES NOT APPLY                   | CENTER LINE IS HIGH IMPEDANCE "OFF" STATE |
|          | MAY CHANGE FROM L TO H | WILL BE CHANGING FROM L TO H |          |                                  |   |

### AC TEST LOAD



BPM-087

## PROGRAMMING

The Am27S28 and Am27S29 are manufactured with a conductive Platinum-Silicide link at each bit location. The output of the memory with the link in place is LOW. The fusible links are opened one at a time by passing current through them from a 20 volt supply which is applied to the memory output after the  $\overline{CS}$  input is at a logic HIGH. Current is gated through the addressed fuse by raising the  $\overline{CS}$  input from a logic HIGH to 15 volts. After 50  $\mu\text{sec}$ , the 20 volt supply is removed, the chip is enabled and the output level is sensed to determine if the link has opened. Most links will open within 50  $\mu\text{sec}$ . Occasionally a link will be stronger and require additional programming cycles. The recommended duration of additional programming periods is 5 msec. If a link has not opened after a total elapsed programming time of 400 msec, further programming of the device should not be attempted. Successive links are programmed in the same manner until all desired bit locations have been programmed to the HIGH level.

Typical current into an output during programming will be approximately 140mA until the fuse link is opened, after which the current drops to approximately 40mA. Current into the  $\overline{CS}$  pin when it is raised to 15 volts is typically 1.5mA.

The memories may become hot during programming due to the large currents being passed. Programming cycles should not be continuously applied to one device more than 5 seconds to avoid heat damage. If this programming time is exceeded, all power to the chip including  $V_{CC}$  should be removed for a period of 5 seconds after which programming may be resumed.

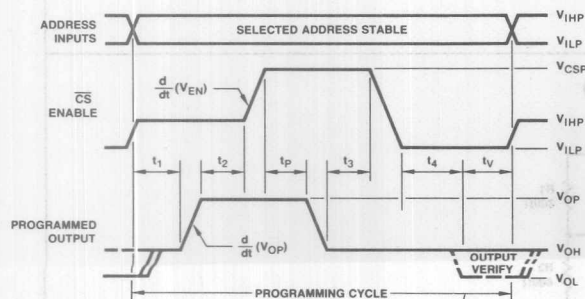
When all programming has been completed, the data content of the memory should be verified by sequentially reading all words. Occasionally this verification will show that an extra undesired link has been fused. Should this occur, immediately check the programming equipment to make sure that all device pins are firmly contacting the programming socket, that the input signal levels exhibit sufficient noise margins, and that the programming voltages are within the specified limits. All of these conditions must be maintained during programming. AMD PROMs are thoroughly tested to minimize unwanted fusing; fusing extra bits is generally related to programming equipment problems.

## PROGRAMMING PARAMETERS

| Parameter      | Description                                | Min. | Max.          | Units              |
|----------------|--|------|---------------|--------------------|
| $V_{CCP}$      | $V_{CC}$ During Programming                | 5.0  | 5.5           | Volts              |
| $V_{IHP}$      | Input HIGH Level During Programming        | 2.4  | 5.5           | Volts              |
| $V_{ILP}$      | Input LOW Level During Programming         | 0.0  | 0.45          | Volts              |
| $V_{CSP}$      | $\overline{CS}$ Voltage During Programming | 14.5 | 15.5          | Volts              |
| $V_{OP}$       | Output Voltage During Programming          | 19.5 | 20.5          | Volts              |
| $V_{ONP}$      | Voltage on Outputs Not to be Programmed    | 0.0  | $V_{CCP}+0.3$ | Volts              |
| $I_{ONP}$      | Current into Outputs Not to be Programmed  |      | 20            | mA                 |
| $d(V_{OP})/dt$ | Rate of Output Voltage Change              | 20   | 250           | V/ $\mu\text{sec}$ |
| $d(V_{EN})/dt$ | Rate of $\overline{CS}_1$ Voltage Change   | 100  | 1000          | V/ $\mu\text{sec}$ |
| $t_p$          | Programming Period – First Attempt         | 50   | 100           | $\mu\text{sec}$    |
|                | Programming Period – Subsequent Attempts   | 5.0  | 15            | msec               |

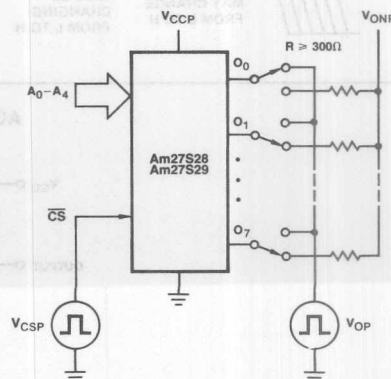
- Notes: 1. All delays between edges are specified from completion of the first edge to beginning of the second edge; i.e., not to the midpoints.  
 2. Delays  $t_1$  through  $t_4$  must be greater than 100ns; maximum delays of 1  $\mu\text{sec}$  are recommended to minimize heating during programming.  
 3. During  $t_v$ , a user defined period, the output being programmed is switched to the load R and read to determine if additional pulses are required.  
 4. Outputs not being programmed are connected to  $V_{ONP}$  through resistor R which provides output current limiting.

## PROGRAMMING WAVEFORMS



BPM-088

## SIMPLIFIED PROGRAMMING DIAGRAM



BPM-089

## PROGRAMMING EQUIPMENT

Generic programming boards and device adapters are available from the sources listed below. In each case, the programming boards are used in these manufacturer's automatic

programmers to program all AMD generic series bipolar PROMs; individual adapters are required for each basic part type in the series.

|   |   |  |
|---|---|--|
| SOURCE AND LOCATION                               | Data I/O Corp.<br>P.O. Box 308<br>Issaquah, Wash. 98027 | Pro-Log Corp.<br>2411 Garden Road<br>Monterey, Ca. 93940 |
| PROGRAMMER MODEL(S)                               | Model 5, 7 and 9  | M900 and M920  |
| AMD GENERIC BIPOLAR<br>PROM PERSONALITY BOARD     | 909-1286-1  | PM9058   |
| Am27S28 • Am27S29<br>ADAPTERS AND<br>CONFIGURATOR | 715-1413  | PA20-4 and 512 x 8 (L)                                   |

## OBTAINING PROGRAMMED UNITS

Programmed devices may be purchased from your distributor or Advanced Micro Devices. The program data should be submitted in the form of a punched paper tape and must be accompanied by a written truth table. The punched tape can be delivered with your order or may be transmitted over a TWX machine or time-sharing terminal. ASCII BPNF is our preferred paper tape format.

Truth tables are also acceptable, however, much less desirable especially for larger density PROMs. Submission of a truth table requires the generation of a punched paper tape at the distributor or factory resulting in longer lead times, greater possibility of error, and higher cost.

## ASCII BPNF

An example of an ASCII tape in the BPNF format is shown below. They can be punched on any Teletype® or on a TWX or Telex machine. The format chosen provides relatively good error detection. Paper tapes must consist of:

1. A leader of at least 25 rubouts.
2. The data patterns for all 512 words, starting with word 0, in the following format:
  - a. Any characters, including carriage return and line feed, except "B".
  - b. The letter "B", indicating the beginning of the data word.
  - c. A sequence of eight Ps or Ns, starting with output O<sub>7</sub>.
  - d. The letter "F", indicating the finish of the data word.
  - e. Any text, including carriage return and line feed, except the letter "B".

3. A trailer of at least 25 rubouts.

A P is a HIGH logic level = 2.4 volts.

An N is a LOW logic level = 0.4 volts.

A convenient pattern to use for the data words is to prefix the word (or every few words) with the word number, then type the data word, then a comment, then carriage return and line feed as shown below. There must be no characters between the B and the F except for the eight Ps and Ns. If an error is made in a word, the entire word must be cancelled with rub-outs back to the letter B, then the word re-typed beginning with the B.

When TWXing your tape, be sure the tape is in even parity. Parity is not necessary if the tape is mailed.

### TYPICAL PAPER TAPE FORMAT

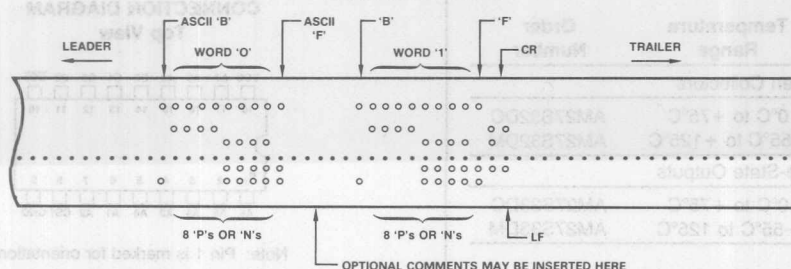
|     |            |                       |
|-----|------------|-----------------------|
| ⓪⓪⓪ | BENPPNNNEF | WORD ZERO (R) (L)     |
|     | BP PPPPPNF | COMMENT FIELD (R) (L) |
| ⓪⓪2 | BNNPPPPNF  | ANY (R) (L)           |
|     | BNNNNNNNF  | TEXT (R) (L)          |
| ⓪⓪4 | BPNNNNNEF  | CAN (R) (L)           |
|     | BNPPPPNNF  | GO (R) (L)            |
| ⓪⓪6 | BPNNPPNNF  | HERE (R) (L)          |
| .   | .....      | .                     |
| 511 | BNNNNPPNF  | END (R) (L)           |

(R) = CARRIAGE RETURN  
(L) = LINE FEED

### RESULTING DEVICE TRUTH TABLE ( $\overline{\text{CS}}$ LOW)

| A <sub>8</sub> | A <sub>7</sub> | A <sub>6</sub> | A <sub>5</sub> | A <sub>4</sub> | A <sub>3</sub> | A <sub>2</sub> | A <sub>1</sub> | A <sub>0</sub> | O <sub>7</sub> | O <sub>6</sub> | O <sub>5</sub> | O <sub>4</sub> | O <sub>3</sub> | O <sub>2</sub> | O <sub>1</sub> | O <sub>0</sub> |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| L              | L              | L              | L              | L              | L              | L              | L              | L              | H              | L              | H              | H              | L              | L              | L              | H              |
| L              | L              | L              | L              | L              | L              | L              | L              | H              | H              | H              | H              | H              | H              | H              | L              | L              |
| L              | L              | L              | L              | L              | L              | L              | H              | L              | L              | L              | H              | H              | H              | H              | H              | L              |
| L              | L              | L              | L              | L              | L              | L              | H              | H              | L              | L              | L              | L              | L              | L              | L              | L              |
| L              | L              | L              | L              | L              | L              | L              | H              | L              | L              | L              | L              | L              | L              | L              | L              | H              |
| L              | L              | L              | L              | L              | L              | H              | L              | H              | L              | H              | H              | L              | H              | H              | L              | L              |
| L              | L              | L              | L              | L              | L              | H              | H              | L              | H              | L              | L              | H              | H              | H              | L              | L              |
|                |                |                |                | ⋮              |                |                |                |                |                |                |                |                | ⋮              |                |                |                |
| H              | H              | H              | H              | H              | H              | H              | H              | H              | L              | L              | L              | L              | H              | H              | H              | H              |

## ASCII PAPER TAPE



# Am27S32 • Am27S33

## 4096-Bit Generic Series Bipolar PROM

### DISTINCTIVE CHARACTERISTICS

- High Speed – 55ns max commercial range access time
- Excellent performance over full MIL and commercial ranges
- Highly reliable, ultra-fast programming Platinum-Silicide fuses
- High programming yield
- Low current PNP inputs
- High current open collector and three-state outputs
- Fast chip select
- Access time tested with  $N^2$  patterns
- Pin for pin replacements for industry standard products
- Common Generic PROM series electrical characteristics and simple programming procedures.

### GENERIC SERIES CHARACTERISTICS

The Am27S32 and Am27S33 are members of an Advanced PROM series incorporating common electrical characteristics and programming procedures. All parts in this series are produced with a fusible link at each memory location storing a logic LOW and can be selectively programmed to a logic HIGH by applying appropriate voltages to the circuit.

All parts are fabricated with AMD's fast programming highly reliable Platinum-Silicide Fuse technology. Utilizing easily implemented programming (and common programming personality card sets) these products can be rapidly programmed to any customized pattern. Extra test words are pre-programmed during manufacturing to insure extremely high field programming yields, and produce excellent parametric correlation.

Platinum-Silicide was selected as the fuse link material to achieve a well controlled melt rate resulting in large non-conductive gaps that ensure very stable long term reliability. Extensive operating testing has proven that this low-field, large-gap technology offers the best reliability for fusible link PROMs.

Common design features include active loading of all critical AC paths regulated by a built-in temperature and voltage compensated bias network to provide excellent parametric performance over MIL supply and temperature ranges. Selective feedback techniques have been employed to minimize delays through all critical paths producing the fastest speeds possible from Schottky processed PROMs.

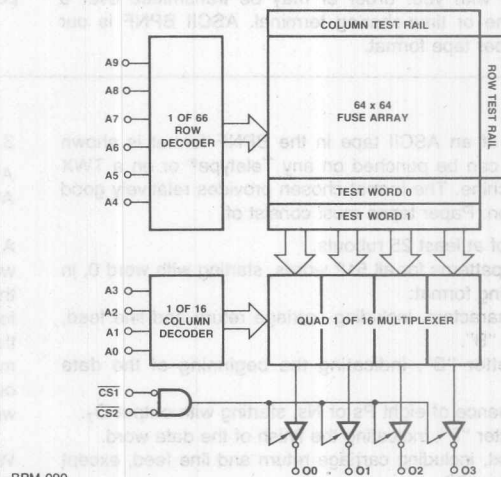
### ORDERING INFORMATION

| Package Type        | Temperature Range | Order Number |
|---------------------|-------------------|--------------|
| Open Collectors     |                   |              |
| Hermetic DIP        | 0°C to +75°C      | AM27S32DC    |
| Hermetic DIP        | -55°C to +125°C   | AM27S32DM    |
| Three-State Outputs |                   |              |
| Hermetic DIP        | 0°C to +75°C      | AM27S33DC    |
| Hermetic DIP        | -55°C to 125°C    | AM27S33DM    |

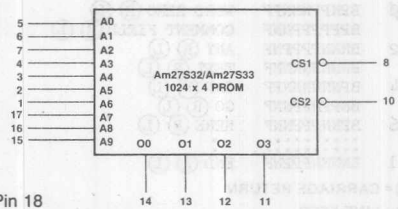
### FUNCTIONAL DESCRIPTION

The Am27S32 and Am27S33 are high speed electrically programmable Schottky read only memories. Organized in the industry standard 1024 x 4 configuration, they are available in both open collector Am27S32 and three-state Am27S33 output versions. After programming, stored information is read on outputs O0–O3 by applying unique binary addresses to A0–A9 and holding the chip select inputs, CS1 and CS2, LOW. If either chip select input goes to a logic HIGH, O0–O3 go to the off or high impedance state.

### BLOCK DIAGRAM



### LOGIC SYMBOL



VCC = Pin 18  
GND = Pin 9

### CONNECTION DIAGRAM Top View



Note: Pin 1 is marked for orientation.



**MAXIMUM RATINGS** (Above which the useful life may be impaired)

|  |                    |
|--|--------------------|
| Storage Temperature  | -65°C to +150°C    |
| Temperature (Ambient) Under Bias   | -55°C to +125°C    |
| Supply Voltage to Ground Potential (Pin 18 to Pin 9) Continuous          | -0.5V to +7.0V     |
| DC Voltage Applied to Outputs (Except During Programming)                | -0.5V to +VCC max. |
| DC Voltage Applied to Outputs During Programming                         | 21V                |
| Output Current into Outputs During Programming (Max. Duration of 1 sec.) | 200mA              |
| DC Input Voltage   | -0.5V to +5.5V     |
| DC Input Current   | -30mA to +5mA      |

**OPERATING RANGE**

|       |                      |  |                                 |
|-------|----------------------|--|---------------------------------|
| COM'L | Am27S32XC, Am27S33XC | $T_A = 0^\circ\text{C to } +75^\circ\text{C}$    | $V_{CC} = 5.0\text{V} \pm 5\%$  |
| MIL   | Am27S32XM, Am27S33XM | $T_A = -55^\circ\text{C to } +125^\circ\text{C}$ | $V_{CC} = 5.0\text{V} \pm 10\%$ |

**ELECTRICAL CHARACTERISTICS OVER OPERATING RANGE** (Unless Otherwise Noted)  
**PRELIMINARY DATA**

| Parameters            | Description                  | Test Conditions   |       | Min.      | Typ.<br>(Note 1) | Max.   | Units |
|-----------------------|------------------------------|---|-------|-----------|------------------|--------|-------|
| VOH<br>(Am27S33 only) | Output HIGH Voltage          | VCC = MIN., IOH = -2.0mA<br>VIN = VIH or VIL            |       | 2.4       |                  |        | Volts |
| VOL                   | Output LOW Voltage           | VCC = MIN., IOL = 16mA<br>VIN = VIH or VIL              |       |           |                  | 0.45   | Volts |
| VIH                   | Input HIGH Level             | Guaranteed input logical HIGH<br>voltage for all inputs |       | 2.0       |                  |        | Volts |
| VIL                   | Input LOW Level              | Guaranteed input logical LOW<br>voltage for all inputs  |       |           |                  | 0.8    | Volts |
| IIL                   | Input LOW Current            | VCC = MAX., VIN = 0.45V                                 |       |           | -0.020           | -0.250 | mA    |
| IIH                   | Input HIGH Current           | VCC = MAX., VIN = 2.7V                                  |       |           |                  | 25     | μA    |
| II                    | Input HIGH Current           | VCC = MAX., VIN = 5.5V                                  |       |           |                  | 1.0    | mA    |
| ISC<br>(Am27S33 only) | Output Short Circuit Current | VCC = MAX., VOUT = 0.0V (Note 2)                        |       | -20       | -40              | -90    | mA    |
| ICC                   | Power Supply Current         | All inputs = GND<br>VCC = MAX.                          | COM'L |           | 105              | 140    | mA    |
|                       |                              |   | MIL   |           | 105              | 145    |       |
| VI                    | Input Clamp Voltage          | VCC = MIN., IIN = -18mA                                 |       |           |                  | -1.2   | Volts |
| ICEX                  | Output Leakage Current       | VCC = MAX.<br>VCS1 = 2.4V<br>Am27S33<br>only            |       | VO = 4.5V |                  | 40     | μA    |
|                       |                              |   |       | VO = 2.4V |                  | 40     |       |
|                       |                              |   |       | VO = 0.4V |                  | -40    |       |
| CIN                   | Input Capacitance            | VIN = 2.0V @ f = 1MHz (Note 3)                          |       |           | 5                |        | pF    |
| COUT                  | Output Capacitance           | VOUT = 2.0V @ f = 1MHz (Note 3)                         |       |           | 12               |        |       |

Notes: 1. Typical limits are at  $V_{CC} = 5.0\text{V}$  and  $T_A = 25^\circ\text{C}$ .

2. Not more than one output should be shorted at a time. Duration of the short circuit should not be more than one second.

3. These parameters are not 100% tested, but are periodically sampled.



# SWITCHING CHARACTERISTICS OVER OPERATING RANGE

## PRELIMINARY DATA

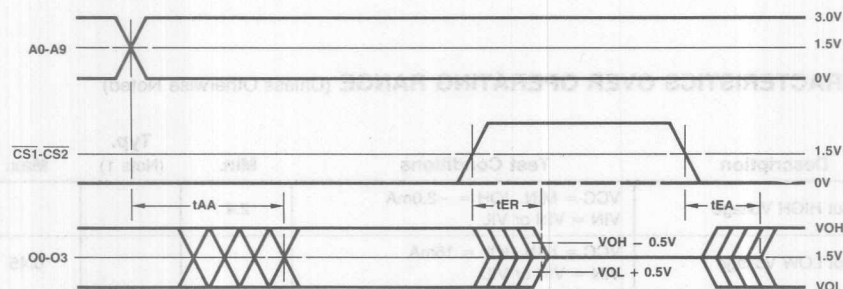
| Parameter | Description          | Test Conditions                 | Typ        | Max   |     | Units |
|-----------|----------------------|---------------------------------|------------|-------|-----|-------|
|           |                      |                                 | 5V<br>25°C | COM'L | MIL |       |
| $t_{AA}$  | Address Access Time  | AC Test Load<br>(See Notes 1-3) | 38         | 55    | 70  | ns    |
| $t_{EA}$  | Enable Access Time   |                                 | 10         | 25    | 30  | ns    |
| $t_{ER}$  | Enable Recovery Time |                                 | 10         | 25    | 30  | ns    |

Notes: 1.  $t_{AA}$  is tested with switch S1 closed and  $CL = 30pF$ .

2. For open collector outputs,  $t_{EA}$  and  $t_{ER}$  are tested with S1 closed to the 1.5V output level.  $CL = 30pF$ .

3. For three state outputs,  $t_{EA}$  is tested with  $CL = 30pF$  to the 1.5V level; S1 is open for high impedance to HIGH tests and closed for high impedance to LOW tests.  $t_{ER}$  is tested with  $CL = 5pF$ . HIGH to high impedance tests are made with S1 open to an output voltage of  $VOH - 0.5V$ ; LOW to high impedance tests are made with S1 closed to the  $VOL + 0.5V$  level.

## SWITCHING CHARACTERISTICS

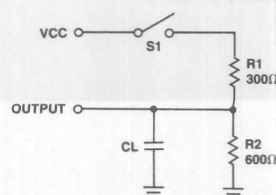


Note: Level on output while either  $\overline{CS}$  is HIGH is determined externally.

## KEY TO TIMING DIAGRAM

| WAVEFORM | INPUTS                 | OUTPUTS                      | WAVEFORM | INPUTS                           | OUTPUTS                                   |
|----------|------------------------|------------------------------|----------|----------------------------------|---|
|          | MUST BE STEADY         | WILL BE STEADY               |          | DON'T CARE; ANY CHANGE PERMITTED | CHANGING; STATE UNKNOWN                   |
|          | MAY CHANGE FROM H TO L | WILL BE CHANGING FROM H TO L |          | DOES NOT APPLY                   | CENTER LINE IS HIGH IMPEDANCE "OFF" STATE |
|          | MAY CHANGE FROM L TO H | WILL BE CHANGING FROM L TO H |          |                                  |   |

## AC TEST LOAD



## PROGRAMMING

The Am27S32 and Am27S33 are manufactured with conductive Platinum-Silicide link at each bit location. The output of the memory with the link in place is LOW. To program the device, the fusible links are selectively opened.

The fusible links are opened one at a time by passing current through them from a 20 volt supply which is applied to one memory output after the  $\overline{CS}_1$  input is at a logic HIGH. Current is gated through the addressed fuse by raising the  $\overline{CS}_1$  input from a logic HIGH to 15 volts. After 50  $\mu$ sec, the 20 volt supply is removed, the chip enabled, and the output level sensed to determine if the link has opened. Most links will open within 50  $\mu$ sec. Occasionally a link will be stronger and require additional programming cycle. The recommended duration of additional programming periods is 5 msec. If a link has not opened after a total elapsed programming time of 400 msec, further programming of the device should not be attempted. Successive links are programmed in the same manner until all desired bit locations have been programmed to the HIGH level.

Typical current into an output during programming will be approximately 140mA until the fuse link is opened, after which

the current drops to approximately 40mA. Current into the  $\overline{CS}_1$  pin when it is raised to 15 volts is typically 1.5mA.

The memories may become hot during programming due to the large currents being passed. Programming cycles should not be applied to one device more than 5 seconds to avoid heat damage. If this programming time is exceeded, all power to the chip including VCC should be removed for a period of 5 seconds after which programming may be resumed.

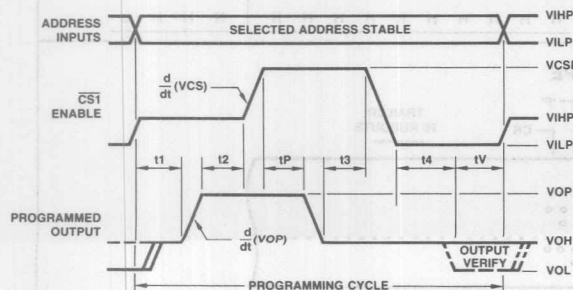
When all programming has been completed, the data content of the memory should be verified by sequentially reading all words. Occasionally this verification will show that an extra undesired link has been fused. Should this occur, immediately check the programming equipment to make sure that all device pins are firmly contacting the programming socket, that the input signal levels exhibit sufficient noise margins, and that the programming voltages are within the specified limits. All of these conditions must be maintained during programming. AMD PROMs are thoroughly tested to minimize unwanted fusing; fusing extra bits is generally related to programming equipment problems.

## PROGRAMMING PARAMETERS

| Parameter | Description                                  | Min. | Max.     | Units        |
|-----------|--|------|----------|--------------|
| VCCP      | VCC During Programming                       | 5.0  | 5.5      | Volts        |
| VIHP      | Input HIGH Level During Programming          | 2.4  | 5.5      | Volts        |
| VILP      | Input LOW Level During Programming           | 0.0  | 0.45     | Volts        |
| VCSP      | $\overline{CS}_1$ Voltage During Programming | 14.5 | 15.5     | Volts        |
| VOP       | Output Voltage During Programming            | 19.5 | 20.5     | Volts        |
| VONP      | Voltage on Outputs. Not to be Programmed     | 0    | VCCP+0.3 | Volts        |
| IONP      | Current into Outputs Not to be Programmed    |      | 20       | mA           |
| d(VOP)/dt | Rate of Output Voltage Change                | 20   | 250      | V/ $\mu$ sec |
| d(VCS)/dt | Rate of $\overline{CS}_1$ Voltage Change     | 100  | 1000     | V/ $\mu$ sec |
| tP        | Programming Period – First Attempt           | 50   | 100      | $\mu$ sec    |
|           | Programming Period – Subsequent Attempts     | 5    | 15       | msec         |

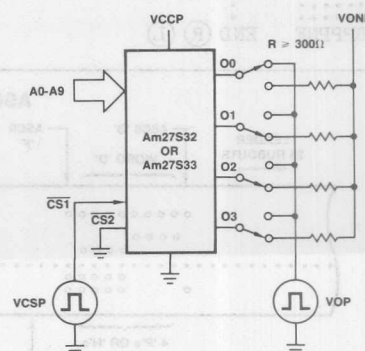
- Notes: 1. All delays between edges are specified from completion of the first edge to beginning of the second edge; i.e. not to the midpoints.  
 2. Delays t1, t2, t3 and t4 must be greater than 100 ns; maximum delays of 1  $\mu$ sec are recommended to minimize heating during programming.  
 3. During tv, a user defined period, the output being programmed is switched to the load R and read to determine if additional pulses are required.  
 4. Outputs not being programmed are connected to VONP through resistor R which provides output current limiting.

### PROGRAMMING WAVEFORMS



BPM-095

### SIMPLIFIED PROGRAMMING DIAGRAM



BPM-096

Generic programming boards and device adapters are available from the sources listed below. In each case, the programming boards are used in these manufacturer's automatic

programmers to program an AMD generic series bipolar PROMs; individual adapters are required for each base part type in the series.

|   |   |  |
|---|---|--|
| SOURCE AND LOCATION                               | Data I/O Corp.<br>P.O. Box 308<br>Issaquah, Wash. 98027 | Pro-Log Corp.<br>2411 Garden Road<br>Monterey, Ca. 93940 |
| PROGRAMMER MODEL(S)                               | Model 5, 7 and 9  | M900 and M920  |
| AMD GENERIC BIPOLAR<br>PROM PERSONALITY BOARD     | 909-1286-1  | PM9058   |
| Am27S32 • Am27S33<br>ADAPTERS AND<br>CONFIGURATOR | 715-1414  | PA 18-6 and 1024 x 4 (L)                                 |

### OBTAINING PROGRAMMED UNITS

Programmed devices may be purchased from your distributor or Advanced Micro Devices. The program data should be submitted in the form of a punched paper tape and must be accompanied by a written truth table. The punched tape can be delivered with your order or may be transmitted over a TWX machine or time-sharing terminal. ASCII BPNF is our preferred paper tape format.

Truth tables are also acceptable, but are much less desirable especially for larger density PROMs. Submission of a truth table requires the generation of a punched paper tape at the distributor or factory resulting in longer lead times, greater possibility of error, and higher cost.

### ASCII BPNF

An example of an ASCII tape in the BPNF format is shown below. They can be punched on any Teletype® or on a TWX or Telex machine. The format chosen provides relatively good error detection. Paper tapes must consist of:

1. A leader of at least 25 rubouts.
2. The data patterns for all 1024 words, starting with word 0, in the following format:
  - a. Any characters, including carriage return and line feed, except "B".
  - b. The letter "B", indicating the beginning of the data word.
  - c. A sequence of four Ps or Ns, starting with output O3.
  - d. The letter "F", indicating the finish of the data word.
  - e. Any text, including carriage return and line feed, except the letter "B".

3. A trailer of at least 25 rubouts.

A P is a HIGH logic level = 2.4 volts.

An N is a LOW logic level = 0.4 volts.

A convenient pattern to use for the data words is to prefix the word (or every few words with the word number, then type the data word, then a comment, then carriage return and line feed as shown below. There must be no characters between the B and the F except for the four Ps and Ns. If an error is made in a word, the entire word must be cancelled with rubouts back to the letter B, then the word re-typed beginning with the B.

When TWXing your tape, be sure the tape is in even parity. Parity is not necessary if the tape is mailed.

### TYPICAL PAPER TAPE FORMAT

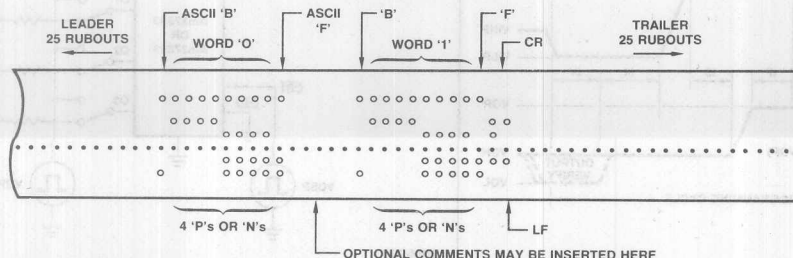
```

000 BNNNPF WORD ZERO (R) (L)
BPPNPF COMMENT FIELD (R) (L)
002 BPPNPF ANY (R) (L)
BNNNPF TEXT (R) (L)
004 BNNNPF CAN (R) (L)
BPPNPF GO (R) (L)
006 BPPNPF HERE (R) (L)
: .....
: .....
1024 BPPNPF END (R) (L)
  
```

### RESULTING DEVICE TRUTH TABLE (CS1 and CS2 = LOW)

| A9 | A8 | A7 | A6 | A5 | A4 | A3 | A2 | A1 | A0 | O3 | O2 | O1 | O0 |
|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| L  | L  | L  | L  | L  | L  | L  | L  | L  | L  | L  | L  | L  | H  |
| L  | L  | L  | L  | L  | L  | L  | L  | L  | H  | H  | H  | L  | L  |
| L  | L  | L  | L  | L  | L  | L  | L  | H  | L  | H  | H  | L  | L  |
| L  | L  | L  | L  | L  | L  | L  | L  | H  | H  | L  | L  | L  | L  |
| L  | L  | L  | L  | L  | L  | L  | H  | L  | L  | L  | L  | L  | H  |
| L  | L  | L  | L  | L  | L  | L  | H  | L  | H  | H  | H  | L  | L  |
| L  | L  | L  | L  | L  | L  | L  | H  | H  | L  | H  | H  | L  | L  |
| H  | H  | H  | H  | H  | H  | H  | H  | H  | H  | H  | H  | H  | L  |

### ASCII PAPER TAPE



BPM-097

# Am27S180 • Am27S181

8192-Bit Generic Series Bipolar PROM

## PRELIMINARY DATA

### DISTINCTIVE CHARACTERISTICS

- High Speed – 60ns max commercial range access time
- Excellent performance over full MIL and commercial ranges
- Highly reliable, ultra-fast programming Platinum-Silicide fuses
- High programming yield
- Low current PNP inputs
- High current open collector and three-state outputs
- Fast chip select
- Access time tested with  $N^2$  patterns
- Pin for pin replacements for industry standard products
- Common Generic PROM series electrical characteristics and simple programming procedures.

### GENERIC SERIES CHARACTERISTICS

The Am27S180 and Am27S181 are members of an Advanced PROM series incorporating common electrical characteristics and programming procedures. All parts in this series are produced with a fusible link at each memory location storing a logic LOW and can be selectively programmed to a logic HIGH by applying appropriate voltages to the circuit.

All parts are fabricated with AMD's fast programming highly reliable Platinum-Silicide Fuse technology. Utilizing easily implemented programming (and common programming personality card sets) these products can be rapidly programmed to any customized pattern. Extra test words are pre-programmed during manufacturing to insure extremely high field programming yields, and produce excellent parametric correlation.

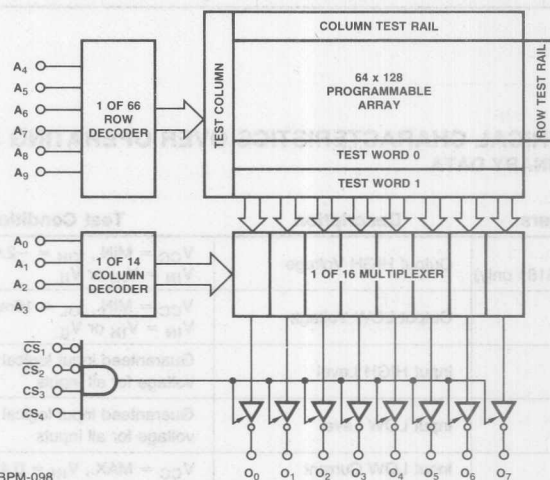
Platinum-Silicide was selected as the fuse link material to achieve a well controlled melt rate resulting in large non-conductive gaps that ensure very stable long term reliability. Extensive operating testing has proven that this low-field, large-gap technology offers the best reliability for fusible link PROMs.

Common design features include active loading of all critical AC paths regulated by a built-in temperature and voltage compensated bias network to provide excellent parametric performance over MIL supply and temperature ranges. Selective feedback techniques have been employed to minimize delays through all critical paths producing the fastest speeds possible from Schottky processed PROMs.

### FUNCTIONAL DESCRIPTION

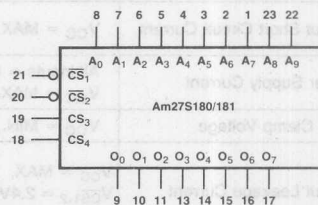
The Am27S180 and Am27S181 are high speed electrically programmable Schottky read only memories. Organized in the industry standard 1024 x 8 configuration, they are available in both open collector Am27S180 and three-state Am27S181 output versions. After programming, stored information is read on outputs  $O_0$ - $O_7$  by applying unique binary addresses to  $A_0$ - $A_9$  and enabling the chip ( $\overline{CS}_1$ ,  $\overline{CS}_2$ , low and  $CS_3$ ,  $CS_4$  high). Changes of chip select input levels disables the outputs causing them to go to the off or high impedance state.

### BLOCK DIAGRAM



BPM-098

### LOGIC DIAGRAM



BPM-099

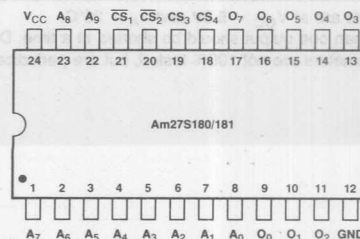
$V_{CC}$  = Pin 24  
GND = Pin 12

### ORDERING INFORMATION

| Package Type        | Temperature Range | Order Number |
|---------------------|-------------------|--------------|
| Open Collectors     |                   |              |
| Hermetic DIP        | 0°C to +75°C      | AM27S180DC   |
| Hermetic DIP        | -55°C to +125°C   | AM27S180DM   |
| Three-State Outputs |                   |              |
| Hermetic DIP        | 0°C to +75°C      | AM27S181DC   |
| Hermetic DIP        | -55°C to +125°C   | AM27S181DM   |

### CONNECTION DIAGRAM

#### Top View



BPM-100

Note: Pin 1 is marked for orientation.



# Am27S180 • Am27S181

## MAXIMUM RATINGS (Above which the useful life may be impaired)

|  |                                |
|--|--------------------------------|
| Storage Temperature  | -65 to +150°C                  |
| Temperature (Ambient) Under Bias   | -55 to +125°C                  |
| Supply Voltage to Ground Potential (Pin 24 to Pin 12) Continuous         | -0.5 to +7.0V                  |
| DC Voltage Applied to Outputs (Except During Programming)                | -0.5V to +V <sub>CC</sub> max. |
| DC Voltage Applied to Outputs During Programming                         | 21V                            |
| Output Current into Outputs During Programming (Max. Duration of 1 sec.) | 200mA                          |
| DC Input Voltage   | -0.5 to +5.5V                  |
| DC Input Current   | -30 to +5mA                    |

## OPERATING RANGE

|       |                        |                                |                             |
|-------|------------------------|--------------------------------|-----------------------------|
| COM'L | Am27S180XC, Am27S181XC | T <sub>A</sub> = 0 to 75°C     | V <sub>CC</sub> = 5.0V ±5%  |
| MIL   | Am27S180XM, Am27S181XM | T <sub>C</sub> = -55 to +125°C | V <sub>CC</sub> = 5.0V ±10% |

## ELECTRICAL CHARACTERISTICS OVER OPERATING RANGE (Unless Otherwise Noted)

### PRELIMINARY DATA

| Parameters                         | Description                  | Test Conditions  | Min. | Typ.<br>(Note 1) | Max.   | Units |
|------------------------------------|------------------------------|--|------|------------------|--------|-------|
| V <sub>OH</sub><br>(Am27S181 only) | Output HIGH Voltage          | V <sub>CC</sub> = MIN., I <sub>OH</sub> = -2.0mA<br>V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub> | 2.4  |                  |        | Volts |
| V <sub>OL</sub>                    | Output LOW Voltage           | V <sub>CC</sub> = MIN., I <sub>OL</sub> = 16mA<br>V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>   |      | 0.38             | 0.50   | Volts |
| V <sub>IH</sub>                    | Input HIGH Level             | Guaranteed input logical HIGH voltage for all inputs   | 2.0  |                  |        | Volts |
| V <sub>IL</sub>                    | Input LOW Level              | Guaranteed input logical LOW voltage for all inputs  |      |                  | 0.8    | Volts |
| I <sub>IL</sub>                    | Input LOW Current            | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 0.45V  |      | -0.010           | -0.250 | mA    |
| I <sub>IH</sub>                    | Input HIGH Current           | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 2.7V   |      |                  | 25     | μA    |
| I <sub>I</sub>                     | Input HIGH Current           | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 5.5V   |      |                  | 1.0    | mA    |
| I <sub>SC</sub><br>(Am27S181 only) | Output Short Circuit Current | V <sub>CC</sub> = MAX., V <sub>OUT</sub> = 0.0V (Note 2)   | -20  | -40              | -90    | mA    |
| I <sub>CC</sub>                    | Power Supply Current         | All inputs = GND<br>V <sub>CC</sub> = MAX.   |      | 120              | 185    | mA    |
| V <sub>I</sub>                     | Input Clamp Voltage          | V <sub>CC</sub> = MIN., I <sub>IN</sub> = -18mA  |      |                  | -1.2   | Volts |
| I <sub>CEX</sub>                   | Output Leakage Current       | V <sub>CC</sub> = MAX,<br>V <sub>CS1,2</sub> = 2.4V<br>V <sub>CS3,4</sub> = 0.4V                         |      |                  | 40     | μA    |
|                                    |                              | Am27S181<br>Only   |      |                  | 40     |       |
|                                    |                              |  |      |                  | -40    |       |
| C <sub>IN</sub>                    | Input Capacitance            | V <sub>IN</sub> = 2.0V @ f = 1MHz (Note 3)   |      | 5                |        | pF    |
| C <sub>OUT</sub>                   | Output Capacitance           | V <sub>OUT</sub> = 2.0V @ f = 1MHz (Note 3)  |      | 12               |        | pF    |

Notes: 1. Typical limits are at V<sub>CC</sub> = 5.0V and T<sub>A</sub> = 25°C.

2. Not more than one output should be shorted at a time. Duration of the short circuit should not be more than one second.

3. These parameters are not 100% tested, but are periodically sampled.



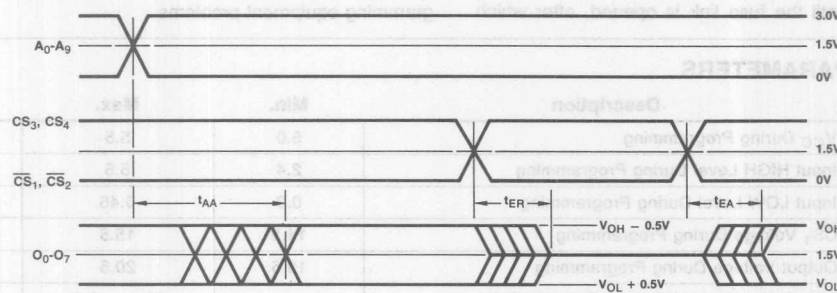
# SWITCHING CHARACTERISTICS OVER OPERATING RANGE

## PRELIMINARY DATA

| Parameter | Description          | Test Conditions                 | Typ        | Max   |     | Units |
|-----------|----------------------|---------------------------------|------------|-------|-----|-------|
|           |                      |                                 | 5V<br>25°C | COM'L | MIL |       |
| $t_{AA}$  | Address Access Time  | AC Test Load<br>(See Notes 1-3) | 40         | 60    | 80  | ns    |
| $t_{EA}$  | Enable Access Time   |                                 | 20         | 40    | 50  | ns    |
| $t_{ER}$  | Enable Recovery Time |                                 | 20         | 40    | 50  | ns    |

- Notes: 1.  $t_{AA}$  is tested with switch  $S_1$  closed and  $C_L = 30\text{pF}$ .  
 2. For open collector outputs,  $t_{EA}$  and  $t_{ER}$  are tested with  $S_1$  closed to the 1.5V output level.  $C_L = 30\text{pF}$ .  
 3. For three state outputs,  $t_{EA}$  is tested with  $C_L = 30\text{pF}$  to the 1.5V level;  $S_1$  is open for high impedance to HIGH tests and closed for high impedance to LOW tests.  $t_{ER}$  is tested with  $C_L = 5\text{pF}$ . HIGH to high impedance tests are made with  $S_1$  open to an output voltage of  $V_{OH} - 0.5\text{V}$ ; LOW to high impedance tests are made with  $S_1$  closed to the  $V_{OL} + 0.5\text{V}$  level.

## SWITCHING CHARACTERISTICS



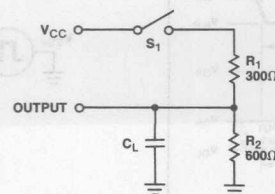
Note: Level on output while either  $\overline{CS}$  is HIGH is determined externally.

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## KEY TO TIMING DIAGRAM

| WAVEFORM | INPUTS                 | OUTPUTS                      | WAVEFORM | INPUTS                           | OUTPUTS                                   |
|----------|------------------------|------------------------------|----------|----------------------------------|---|
|          | MUST BE STEADY         | WILL BE STEADY               |          | DON'T CARE; ANY CHANGE PERMITTED | CHANGING; STATE UNKNOWN                   |
|          | MAY CHANGE FROM H TO L | WILL BE CHANGING FROM H TO L |          | DOES NOT APPLY                   | CENTER LINE IS HIGH IMPEDANCE "OFF" STATE |
|          | MAY CHANGE FROM L TO H | WILL BE CHANGING FROM L TO H |          |                                  |   |

## AC TEST LOAD



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The Am27S180 and Am27S181 are manufactured with a conductive Platinum-Silicide link at each bit location. The output of the memory with the link in place is LOW. To program the device, the fusible links are selectively opened.

The fusible links are opened one at a time by passing current through them from a 20 volt supply which is applied to one memory output after the  $\overline{CS}_1$  input is at a logic HIGH. Current is gated through the addressed fuse by raising the  $\overline{CS}_1$  input from a logic HIGH to 15 volts. After 50  $\mu$ sec, the 20 volt supply is removed, the chip enabled, and the output level sensed to determine if the link has opened. Most links will open within 50  $\mu$ sec. Occasionally a link will be stronger and require additional programming cycles. The recommended duration of additional programming periods is 5 msec. If a link has not opened after a total elapsed programming time of 400 msec, further programming of the device should not be attempted. Successive links are programmed in the same manner until all desired bit locations have been programmed to the HIGH level.

Typical current into an output during programming will be approximately 140mA until the fuse link is opened, after which

the current drops to approximately 40mA. Current into the  $\overline{CS}_1$  pin when it is raised to 15 volts is typically 1.5mA.

The memories may become hot during programming due to the large currents being passed. Programming cycles should not be applied to one device more than 5 seconds to avoid heat damage. If this programming time is exceeded, all power to the chip including  $V_{CC}$  should be removed for a period of 5 seconds after which programming may be resumed.

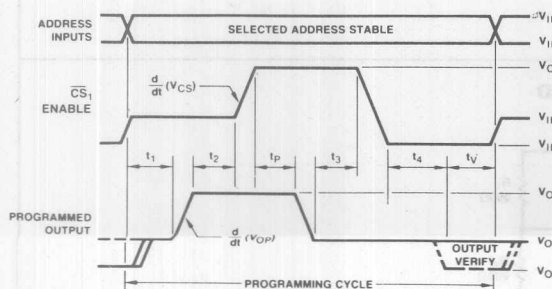
When all programming has been completed, the data content of the memory should be verified by sequentially reading all words. Occasionally this verification will show that an extra undesired link has been fused. Should this occur, immediately check the programming equipment to make sure that all device pins are firmly contacting the programming socket, that the input signal levels exhibit sufficient noise margins, and that the programming voltages are within the specified limits. All of these conditions must be maintained during programming. AMD PROMs are thoroughly tested to minimize unwanted fusing; fusing extra bits is generally related to programming equipment problems.

## PROGRAMMING PARAMETERS

| Parameter      | Description                                  | Min. | Max.            | Units        |
|----------------|--|------|-----------------|--------------|
| $V_{CCP}$      | $V_{CC}$ During Programming                  | 5.0  | 5.5             | Volts        |
| $V_{IHP}$      | Input HIGH Level During Programming          | 2.4  | 5.5             | Volts        |
| $V_{ILP}$      | Input LOW Level During Programming           | 0.0  | 0.45            | Volts        |
| $V_{CSP}$      | $\overline{CS}_1$ Voltage During Programming | 14.5 | 15.5            | Volts        |
| $V_{OP}$       | Output Voltage During Programming            | 19.5 | 20.5            | Volts        |
| $V_{ONP}$      | Voltage on Outputs Not to be Programmed      | 0    | $V_{CCP} + 0.3$ | Volts        |
| $I_{ONP}$      | Current into Outputs Not to be Programmed    |      | 20              | mA           |
| $d(V_{OP})/dt$ | Rate of Output Voltage Change                | 20   | 250             | V/ $\mu$ sec |
| $d(V_{CS})/dt$ | Rate of $\overline{CS}_1$ Voltage Change     | 100  | 1000            | V/ $\mu$ sec |
| $t_p$          | Programming Period – First Attempt           | 50   | 100             | $\mu$ sec    |
|                | Programming Period – Subsequent Attempts     | 5.0  | 15              | msec         |

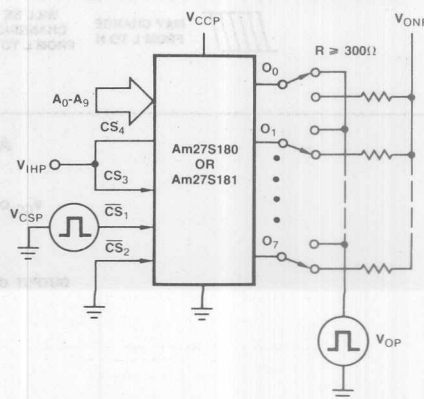
- Notes: 1. All delays between edges are specified from completion of the first edge to beginning of the second edge; i.e., not to the midpoints.  
2. Delays  $t_1$ ,  $t_2$ ,  $t_3$  and  $t_4$  must be greater than 100 ns; maximum delays of 1  $\mu$ sec are recommended to minimize heating during programming.  
3. During  $t_v$ , a user defined period, the output being programmed is switched to the load R and read to determine if additional pulses are required.  
4. Outputs not being programmed are connected to  $V_{ONP}$  through resistor R which provides output current limiting.

### PROGRAMMING WAVEFORMS



BPM-103

### SIMPLIFIED PROGRAMMING DIAGRAM



BPM-104

## PROGRAMMING EQUIPMENT

Generic programming boards and device adapters are available from the sources listed below. In each case, the programming boards are used in these manufacturer's automatic

programmers to program all AMD generic series bipolar PROMs; individual adapters are required for each basic part type in the series.

|   |   |  |
|---|---|--|
| SOURCE AND LOCATION                           | Data I/O Corp.<br>P.O. Box 308<br>Issaquah, Wash. 98027 | Pro-Log Corp.<br>2411 Garden Road<br>Monterey, Ca. 93940 |
| PROGRAMMER MODEL(S)                           | Model 5, 7 and 9  | M900 and M920  |
| AMD GENERIC BIPOLAR<br>PROM PERSONALITY BOARD | 909-1286-1  | PM9058   |
| Am27S180 • Am27S181                           | 715-1545-2  | PA24-13 and 1024 x 8 (L)                                 |
| ADAPTERS AND<br>CONFIGURATOR                  |   |  |

## OBTAINING PROGRAMMED UNITS

Programmed devices may be purchased from your distributor or Advanced Micro Devices. The program data should be submitted in the form of a punched paper tape and must be accompanied by a written truth table. The punched tape can be delivered with your order or may be transmitted over a TWX machine or time-sharing terminal. ASCII BPNF is our preferred paper tape format.

Truth tables are also acceptable, however, much less desirable especially for larger density PROMs. Submission of a truth table requires the generation of a punched paper tape at the distributor or factory resulting in longer lead times, greater possibility of error, and higher cost.

**ASCII BPNF**

An example of an ASCII tape in the BPNF format is shown below. They can be punched on any Teletype® or on a TWX or Telex machine. The format chosen provides relatively good error detection. Paper tapes must consist of:

1. A leader of at least 25 rubouts.
2. The data patterns for all 1024 words, starting with word 0, in the following format:
  - a. Any characters, including carriage return and line feed, except "B".
  - b. The letter "B", indicating the beginning of the data word.
  - c. A sequence of eight Ps or Ns, starting with output O<sub>7</sub>.
  - d. The letter "F", indicating the finish of the data word.
  - e. Any text, including carriage return and line feed, except the letter "B".

3. A trailer of at least 25 rubouts.

A P is a HIGH logic level = 2.4 volts.

An N is a LOW logic level = 0.4 volts.

A convenient pattern to use for the data words is to prefix the word (or every few words) with the word number, then type the data word, then a comment, then carriage return and line feed as shown below. There must be no characters between the B and the F except for the eight Ps and Ns. If an error is made in a word, the entire word must be cancelled with rub-outs back to the letter B, then the word re-typed beginning with the B.

When TWXing your tape, be sure the tape is in even parity. Parity is not necessary if the tape is mailed.

### TYPICAL PAPER TAPE FORMAT

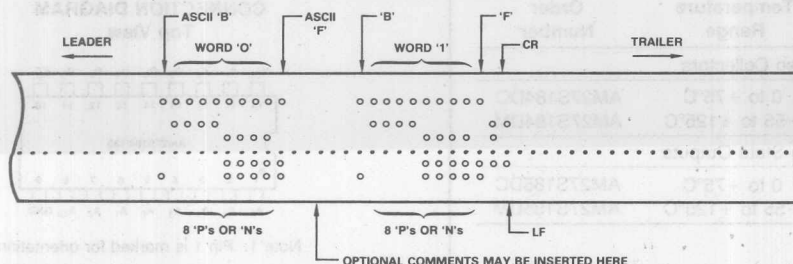
|      |            |               |     |     |
|------|------------|---------------|-----|-----|
| 000  | BPNNPPNNPF | WORD ZERO     | (R) | (L) |
|      | BPPPPPPNNF | COMMENT FIELD | (R) | (L) |
| 002  | BNNNPPNNPF | ANY           | (R) | (L) |
|      | BNNNNNNNNF | TEXT          | (R) | (L) |
| 004  | BPNNNNNNPF | CAN           | (R) | (L) |
|      | BNPPNPPNNF | GO            | (R) | (L) |
| 006  | BPNNPPPPNF | HERE          | (R) | (L) |
| .    | .....      | :             |     |     |
| 1023 | BNNNNPPNNF | END           | (R) | (L) |

Ⓜ = CARRIAGE RETURN  
Ⓛ = LINE FEED

**RESULTING DEVICE TRUTH TABLE**  
( $\overline{CS}_1$  AND  $\overline{CS}_2$  LOW,  $CS_3$  AND  $CS_4$  HIGH)

| A <sub>9</sub> | A <sub>8</sub> | A <sub>7</sub> | A <sub>6</sub> | A <sub>5</sub> | A <sub>4</sub> | A <sub>3</sub> | A <sub>2</sub> | A <sub>1</sub> | A <sub>0</sub> | O <sub>7</sub> | O <sub>6</sub> | O <sub>5</sub> | O <sub>4</sub> | O <sub>3</sub> | O <sub>2</sub> | O <sub>1</sub> | O <sub>0</sub> |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| L              | L              | L              | L              | L              | L              | L              | L              | L              | L              | H              | L              | H              | H              | H              | L              | L              | L              |
| L              | L              | L              | L              | L              | L              | L              | L              | L              | H              | H              | H              | H              | H              | H              | L              | L              | L              |
| L              | L              | L              | L              | L              | L              | L              | L              | H              | L              | L              | L              | H              | H              | H              | H              | L              | L              |
| L              | L              | L              | L              | L              | L              | L              | L              | H              | H              | L              | L              | L              | L              | L              | L              | L              | L              |
| L              | L              | L              | L              | L              | L              | L              | H              | L              | L              | H              | L              | L              | L              | L              | L              | H              | L              |
| L              | L              | L              | L              | L              | L              | H              | L              | H              | L              | H              | L              | H              | H              | H              | L              | L              | L              |
| L              | L              | L              | L              | L              | L              | H              | H              | L              | L              | H              | L              | H              | H              | L              | L              | L              | L              |
| H              | H              | H              | H              | H              | H              | H              | H              | H              | H              | L              | L              | L              | L              | H              | H              | H              | L              |

## ASCII PAPER TAPE



# Am27S184 • Am27S185

8192-Bit Generic Series Bipolar PROM

## PRELIMINARY DATA

### DISTINCTIVE CHARACTERISTICS

- Excellent performance over full MIL and commercial ranges
- Highly reliable, ultra-fast programming Platinum-Silicide fuses
- High programming yield
- Low current PNP inputs
- High current open collector and three-state outputs
- Fast chip select
- Access time tested with  $N^2$  patterns
- Pin for pin replacements for industry standard products
- Common Generic PROM series electrical characteristics and simple programming procedures.

### GENERIC SERIES CHARACTERISTICS

The Am27S184 and Am27S185 are members of an Advanced PROM series incorporating common electrical characteristics and programming procedures. All parts in this series are produced with a fusible link at each memory location storing a logic LOW and can be selectively programmed to a logic HIGH by applying appropriate voltages to the circuit.

All parts are fabricated with AMD's fast programming highly reliable Platinum-Silicide Fuse technology. Utilizing easily implemented programming (and common programming personal-ity card sets) these products can be rapidly programmed to any customized pattern. Extra test words are pre-programmed during manufacturing to insure extremely high field programming yields, and produce excellent parametric correlation.

Platinum-Silicide was selected as the fuse link material to achieve a well controlled melt rate resulting in large non-conductive gaps that ensure very stable long term reliability. Extensive operating testing has proven that this low-field, large-gap technology offers the best reliability for fusible link PROMs.

Common design features include active loading of all critical AC paths regulated by a built-in temperature and voltage compensated bias network to provide excellent parametric performance over MIL supply and temperature ranges. Selective feedback techniques have been employed to minimize delays through all critical paths producing the fastest speeds possible from Schottky processed PROMs.

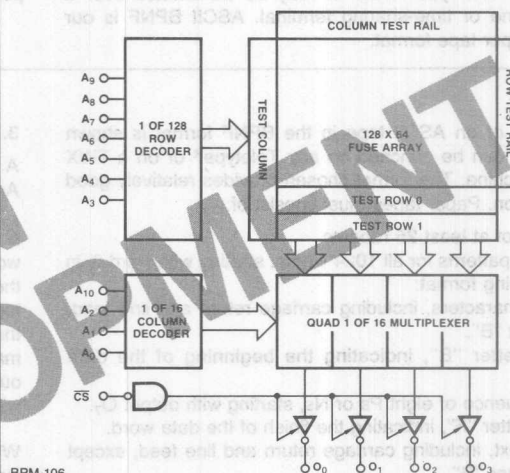
### ORDERING INFORMATION

| Package Type        | Temperature Range | Order Number |
|---------------------|-------------------|--------------|
| Open Collectors     |                   |              |
| Hermetic DIP        | 0 to +75°C        | AM27S184DC   |
| Hermetic DIP        | -55 to +125°C     | AM27S184DM   |
| Three-State Outputs |                   |              |
| Hermetic DIP        | 0 to +75°C        | AM27S185DC   |
| Hermetic DIP        | -55 to +125°C     | AM27S185DM   |

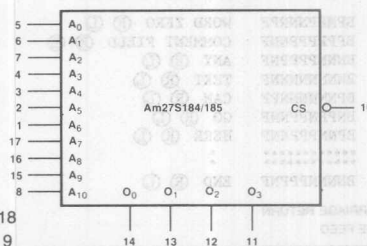
### FUNCTIONAL DESCRIPTION

The Am27S184 and Am27S185 are high speed electrically programmable Schottky read only memories. Organized in the industry standard 2048 x 4 configuration, they are available in both open collector Am27S184 and three-state Am27S185 output versions. After programming, stored information is read on outputs  $O_0$ - $O_3$  by applying unique binary addresses to  $A_0$ - $A_{10}$  and holding the chip select input  $CS$  LOW. If the chip select input goes to a logic HIGH,  $O_0$ - $O_3$  go to the off or high-impedance state.

### BLOCK DIAGRAM

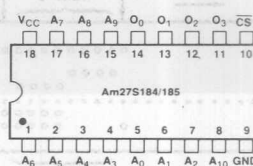


### LOGIC SYMBOL



$V_{CC}$  = Pin 18  
GND = Pin 9

### CONNECTION DIAGRAM Top View



Note 1: Pin 1 is marked for orientation



**MAXIMUM RATINGS** (Above which the useful life may be impaired)

|  |                                |
|--|--------------------------------|
| Storage Temperature  | -65 to +150°C                  |
| Temperature (Ambient) Under Bias   | -55 to +125°C                  |
| Supply Voltage to Ground Potential (Pin 18 to Pin 9) Continuous          | -0.5 to +7.0V                  |
| DC Voltage Applied to Outputs (Except During Programming)                | -0.5V to +V <sub>CC</sub> max. |
| DC Voltage Applied to Outputs During Programming                         | 21V                            |
| Output Current into Outputs During Programming (Max. Duration of 1 sec.) | 200mA                          |
| DC Input Voltage   | -0.5 to +5.5V                  |
| DC Input Current   | -30 to +5mA                    |

**OPERATING RANGE**

|       |                        |                                |                             |
|-------|------------------------|--------------------------------|-----------------------------|
| COM'L | Am27S184XC, Am27S185XC | T <sub>A</sub> = 0 to 75°C     | V <sub>CC</sub> = 5.0V ±5%  |
| MIL   | Am27S184XM, Am27S185XM | T <sub>C</sub> = -55 to +125°C | V <sub>CC</sub> = 5.0V ±10% |

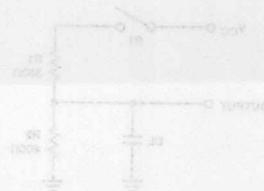
**ELECTRICAL CHARACTERISTICS OVER OPERATING RANGE** (Unless Otherwise Noted)  
**PRELIMINARY DATA**

| Parameters                         | Description                  | Test Conditions  | Min           | Typ<br>(Note 1) | Max   | Units |
|------------------------------------|------------------------------|--|---------------|-----------------|-------|-------|
| V <sub>OH</sub><br>(Am27S185 only) | Output HIGH Voltage          | V <sub>CC</sub> = MIN., I <sub>OH</sub> = -2.0mA<br>V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub> | 2.4           |                 |       | Volts |
| V <sub>OL</sub>                    | Output LOW Voltage           | V <sub>CC</sub> = MIN., I <sub>OL</sub> = 16mA<br>V <sub>IN</sub> = V <sub>IH</sub> or V <sub>IL</sub>   |               |                 | 0.50  | Volts |
| V <sub>IH</sub>                    | Input HIGH Level             | Guaranteed input logical HIGH voltage for all inputs   | 2.0           |                 |       | Volts |
| V <sub>IL</sub>                    | Input LOW Level              | Guaranteed input logical LOW voltage for all inputs  |               |                 | 0.8   | Volts |
| I <sub>IL</sub>                    | Input LOW Current            | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 0.45V  |               | -0.020          | -.250 | mA    |
| I <sub>IH</sub>                    | Input HIGH Current           | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 2.7V   |               |                 | 25    | μA    |
| I <sub>I</sub>                     | Input HIGH Current           | V <sub>CC</sub> = MAX., V <sub>IN</sub> = 5.5V   |               |                 | 40    | mA    |
| I <sub>SC</sub><br>(Am27S185 only) | Output Short Circuit Current | V <sub>CC</sub> = MAX., V <sub>OUT</sub> = 0.0V (Note 2)   | -20           | -45             | -90   | mA    |
| I <sub>CC</sub>                    | Power Supply Current         | All inputs = GND<br>V <sub>CC</sub> = MAX.   |               | 80              | 130   | mA    |
| V <sub>I</sub>                     | Input Clamp Voltage          | V <sub>CC</sub> = MIN., I <sub>IN</sub> = -18mA  |               |                 | -1.2  | Volts |
| I <sub>CEx</sub>                   | Output Leakage Current       | V <sub>CC</sub> = MAX<br>V <sub>CS</sub> = 2.4V  | Am27S185 only |                 | 40    | μA    |
|                                    |                              | V <sub>O</sub> = V <sub>CC</sub><br>V <sub>O</sub> = 0.4V  |               |                 | -40   |       |
| C <sub>IN</sub>                    | Input Capacitance            | V <sub>IN</sub> = 2.0V @ f = 1MHz (Note 3)   |               | 5               |       | pF    |
| C <sub>OUT</sub>                   | Output Capacitance           | V <sub>OUT</sub> = 2.0V @ f = 1MHz (Note 3)  |               | 8               |       |       |

Notes: 1. Typical limits are at V<sub>CC</sub> = 5.0V and T<sub>A</sub> = 25°C.

2. Not more than one output should be shorted at a time. Duration of the short circuit should not be more than one second.

3. These parameters are not 100% tested, but are periodically sampled.



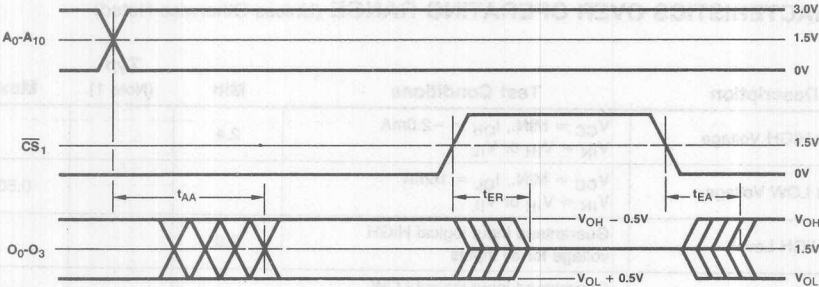


SWITCHING CHARACTERISTICS OVER OPERATING RANGE  
PRELIMINARY DATA

| Parameter       | Description          | Test Conditions                 | Typ        | Max   |     | Units |
|-----------------|----------------------|---------------------------------|------------|-------|-----|-------|
|                 |                      |                                 | 5V<br>25°C | COM'L | MIL |       |
| t <sub>AA</sub> | Address Access Time  | AC Test Load<br>(See Notes 1-3) | 40         | —     | —   | ns    |
| t <sub>EA</sub> | Enable Access Time   |                                 | 10         | —     | —   | ns    |
| t <sub>ER</sub> | Enable Recovery Time |                                 | 10         | —     | —   | ns    |

- Notes: 1. t<sub>AA</sub> is tested with switch S<sub>1</sub> closed and C<sub>L</sub> = 30pF.  
2. For open collector outputs, t<sub>EA</sub> and t<sub>ER</sub> are tested with S<sub>1</sub> closed to the 1.5V output level. C<sub>L</sub> = 30pF.  
3. For three state outputs, t<sub>EA</sub> is tested with C<sub>L</sub> = 30pF to the 1.5V level; S<sub>1</sub> is open for high impedance to HIGH tests and closed for high impedance to LOW tests. t<sub>ER</sub> is tested with C<sub>L</sub> = 5pF. HIGH to high impedance tests are made with S<sub>1</sub> open to an output voltage of V<sub>OH</sub> - 0.5V; LOW to high impedance tests are made with S<sub>1</sub> closed to the V<sub>OL</sub> + 0.5V level.

SWITCHING CHARACTERISTICS



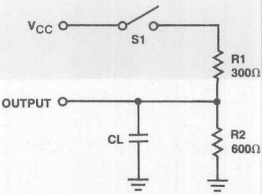
Note: Level on output while either  $\overline{CS}_1$  is HIGH is determined externally.

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KEY TO TIMING DIAGRAM

| WAVEFORM | INPUTS                 | OUTPUTS                      | WAVEFORM | INPUTS                          | OUTPUTS                                   |
|----------|------------------------|------------------------------|----------|---------------------------------|---|
|          | MUST BE STEADY         | WILL BE STEADY               |          | DON'T CARE; ANYCHANGE PERMITTED | CHANGING; STATE UNKNOWN                   |
|          | MAY CHANGE FROM H TO L | WILL BE CHANGING FROM H TO L |          | DOES NOT APPLY                  | CENTER LINE IS HIGH IMPEDANCE "OFF" STATE |
|          | MAY CHANGE FROM L TO H | WILL BE CHANGING FROM L TO H |          |                                 |   |

AC TEST LOAD



BPM-110

## PROGRAMMING

The Am27S184 and Am27S185 are manufactured with conductive Platinum-Silicide link at each bit location. The output of the memory with the link in place is LOW. To program the device, the fusible links are selectively opened.

The fusible links are opened one at a time by passing current through them from a 20 volt supply which is applied to one memory output after the  $\overline{CS}$  input is a logic HIGH. Current is gated through the addressed fuse by raising the  $\overline{CS}$  input from a logic HIGH to 15 volts. After 50  $\mu\text{sec}$ , the 20 volt supply is removed, the chip enabled, and the output level sensed to determine if the link has opened. Most links will open within 50  $\mu\text{sec}$ . Occasionally a link will be stronger and require additional programming cycles. The recommended duration of additional programming periods is 5 msec. If a link has not opened after a total elapsed programming time of 400 msec, further programming of the device should not be attempted. Successive links are programmed in the same manner until all desired bit locations have been programmed to the HIGH level.

Typical current into an output during programming will be approximately 140mA until the fuse link is opened, after which

the current drops to approximately 40mA. Current into the  $\overline{CS}$  pin when it is raised to 15 volts is typically 1.5mA.

The memories may become hot during programming due to the large currents being passed. Programming cycles should not be applied to one device more than 5 seconds to avoid heat damage. If this programming time is exceeded, all power to the chip including  $V_{CC}$  should be removed for a period of 5 seconds after which programming may be resumed.

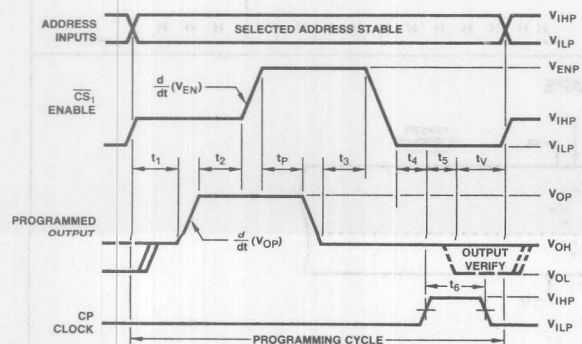
When all programming has been completed, the data content of the memory should be verified by sequentially reading all words. Occasionally this verification will show that an extra undesired link has been fused. Should this occur, immediately check the programming equipment to make sure that all device pins are firmly contacting the programming socket, that the input signal levels exhibit sufficient noise margins, and that the programming voltages are within the specified limits. All of these conditions must be maintained during programming. AMD PROMs are thoroughly tested to minimize unwanted fusing; fusing extra bits is generally related to programming equipment problems.

## PROGRAMMING PARAMETERS

| Parameter      | Description                                | Min  | Max             | Units              |
|----------------|--|------|-----------------|--------------------|
| $V_{CCP}$      | $V_{CC}$ During Programming                | 5.0  | 5.5             | Volts              |
| $V_{IHP}$      | Input HIGH Level During Programming        | 2.4  | 5.5             | Volts              |
| $V_{ILP}$      | Input LOW Level During Programming         | 0.0  | 0.45            | Volts              |
| $V_{CSP}$      | $\overline{CS}$ Voltage During Programming | 14.5 | 15.5            | Volts              |
| $V_{OP}$       | Output Voltage During Programming          | 19.5 | 20.5            | Volts              |
| $V_{ONP}$      | Voltage on Outputs Not to be Programmed    | 0    | $V_{CCP} + 0.3$ | Volts              |
| $I_{ONP}$      | Current into Outputs Not to be Programmed  |      | 20              | mA                 |
| $d(V_{OP})/dt$ | Rate of Output Voltage Change              | 20   | 250             | V/ $\mu\text{sec}$ |
| $d(V_{CS})/dt$ | Rate of $\overline{CS}$ Voltage Change     | 100  | 1000            | V/ $\mu\text{sec}$ |
| $t_p$          | Programming Period – First Attempt         | 50   | 100             | $\mu\text{sec}$    |
|                | Programming Period – Subsequent Attempts   | 5.0  | 15              | msec               |

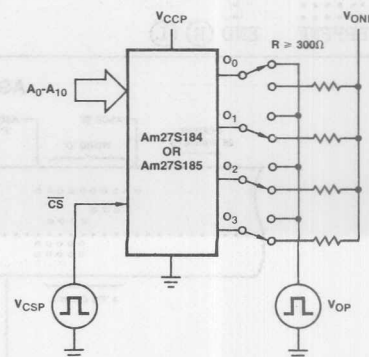
- Notes: 1. All delays between edges are specified from completion of the first edge to beginning of the second edge; i.e., not to the midpoints.  
 2. Delays  $t_1$ ,  $t_2$ ,  $t_3$  and  $t_4$  must be greater than 100 ns; maximum delays of 1  $\mu\text{sec}$  are recommended to minimize heating during programming.  
 3. During  $t_v$ , a user defined period, the output being programmed is switched to the load R and read to determine if additional pulses are required.  
 4. Outputs not being programmed are connected to  $V_{ONP}$  through resistor R which provides output current limiting.

### PROGRAMMING WAVEFORMS



BPM-111

### SIMPLIFIED PROGRAMMING DIAGRAM



BPM-112

## PROGRAMMING EQUIPMENT

Generic programming boards and device adapters are available from the sources listed below. In each case, the programming boards are used in these manufacturer's automatic

programmers to program all AMD generic series bipolar PROMs; individual adapters are required for each basic part type in the series.

|   |   |  |
|---|---|--|
| SOURCE AND LOCATION                           | Data I/O Corp.<br>P.O. Box 308<br>Issaquah, Wash. 98027 | Pro-Log Corp.<br>2411 Garden Road<br>Monterey, Ca. 93940 |
| PROGRAMMER MODEL(S)                           | Model 5, 7 and 9  | M900 and M920  |
| AMD GENERIC BIPOLAR PROM PERSONALITY BOARD    | 909-1286-1  | PM9058   |
| Am27S184 • Am27S185 ADAPTERS AND CONFIGURATOR | 715-1616  | PA18-8 and 2048 x 4 (L)                                  |

## OBTAINING PROGRAMMED UNITS

Programmed devices may be purchased from your distributor or Advanced Micro Devices. The program data should be submitted in the form of a punched paper tape and must be accompanied by a written truth table. The punched tape can be delivered with your order or may be transmitted over a TWX machine or time-sharing terminal. ASCII BPNF is our preferred paper tape format.

Truth tables are also acceptable, but are much less desirable especially for larger density PROMs. Submission of a truth table requires the generation of a punched paper tape at the distributor or factory resulting in longer lead times, greater possibility of error, and higher cost.

## ASCII BPNF

An example of an ASCII tape in the BPNF format is shown below. They can be punched on any Teletype® or on a TWX or Telex machine. The format chosen provides relatively good error detection. Paper tapes must consist of:

1. A leader of at least 25 rubouts.
2. The data patterns for all 2048 words, starting with word 0, in the following format:
  - a. Any characters, including carriage return and line feed, except "B".
  - b. The letter "B", indicating the beginning of the data word.
  - c. A sequence of four Ps or Ns, starting with output O<sub>3</sub>.
  - d. The letter "F", indicating the finish of the data word.
  - e. Any text, including carriage return and line feed, except the letter "B".

3. A trailer of at least 25 rubouts.

A P is a HIGH logic level = 2.4 volts.

An N is a LOW logic level = 0.4 volts.

A convenient pattern to use for the data words is to prefix the word (or every few words with the word number, then type the data word, then a comment, then carriage return and line feed as shown below. There must be no characters between the B and the F except for the four Ps and Ns. If an error is made in a word, the entire word must be cancelled with rubouts back to the letter B, then the word re-typed beginning with the B.

When TWXing your tape, be sure the tape is in even parity. Parity is not necessary if the tape is mailed.

## TYPICAL PAPER TAPE FORMAT

```

000 BNNNPF WORD ZERO (R) (L)
002 BPPNPF COMMENT FIELD (R) (L)
004 BNNNPF ANY (R) (L)
006 BNNNPF TEXT (R) (L)
010 BNNNPF CAN (R) (L)
012 BPPNPF GO (R) (L)
014 BPPNPF HERE (R) (L)
016 .....
018 .....
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## ADVANCED MOS/LSI

Advanced Micro Devices is an industry leader in the production of high-technology MOS products. The company's n-channel, silicon-gate MOS process is ideally suited for the dense, high-speed memory and microprocessor products required by today's systems.

Although most of the MOS products are oriented toward the Am9080A 8-bit MOS microprocessor, the static RAM's are ideal for use with the Am2900 family. The access times of these devices are often well matched to 2900 system microcycle times and provide significant cost benefits over bipolar memories of the same density.

Of particular interest to users of the Am2900 family are the Am9244/9044 and Am9124/9114 4096-bit RAMs. These devices are organized as 4K x 1 and as 1K x 4 and are available with access times to 200ns. The Am9147 is a 4K x 1 bit with access times as fast as 55ns.

Complete data on these devices is included in the following pages, along with our 16K dynamic RAM, the Am9016. The selection guide on the next few pages lists other Advanced MOS products which may be of interest. Most of these products are available for full military temperature range operation. For complete data on our MOS products, see our MOS/LSI Data Book.





# MOS MEMORY SELECTION GUIDE

## STATIC R/W RANDOM-ACCESS MEMORIES

| Part Number | Organization | Maximum Access Time (ns) | Temp. Range | Supply Voltage | Outputs | Data I/O Configuration | Package Pins | Operating Power Max. (mW) | Standby Power Max. (mW) |
|-------------|--------------|--------------------------|-------------|----------------|---------|------------------------|--------------|---------------------------|-------------------------|
| Am9101A     | 256 x 4      | 500                      | C, M        | +5             | 3-State | Separate               | 22           | 290                       | 46                      |
| Am91L01A    | 256 x 4      | 500                      | C, M        | +5             | 3-State | Separate               | 22           | 173                       | 37                      |
| Am9101B     | 256 x 4      | 400                      | C, M        | +5             | 3-State | Separate               | 22           | 290                       | 46                      |
| Am91L01B    | 256 x 4      | 400                      | C, M        | +5             | 3-State | Separate               | 22           | 173                       | 37                      |
| Am9101C     | 256 x 4      | 300                      | C, M        | +5             | 3-State | Separate               | 22           | 315                       | 46                      |
| Am91L01C    | 256 x 4      | 300                      | C, M        | +5             | 3-State | Separate               | 22           | 189                       | 37                      |
| Am9101D     | 256 x 4      | 250                      | C           | +5             | 3-State | Separate               | 22           | 315                       | 46                      |
| Am9102      | 1024 x 1     | 650                      | C, M        | +5             | 3-State | Separate               | 16           | 263                       | 42                      |
| Am91L02     | 1024 x 1     | 650                      | C, M        | +5             | 3-State | Separate               | 16           | 158                       | 35                      |
| Am9102A     | 1024 x 1     | 500                      | C, M        | +5             | 3-State | Separate               | 16           | 263                       | 42                      |
| Am91L02A    | 1024 x 1     | 500                      | C, M        | +5             | 3-State | Separate               | 16           | 158                       | 35                      |
| Am9102B     | 1024 x 1     | 400                      | C, M        | +5             | 3-State | Separate               | 16           | 263                       | 42                      |
| Am91L02B    | 1024 x 1     | 400                      | C, M        | +5             | 3-State | Separate               | 16           | 158                       | 35                      |
| Am9102C     | 1024 x 1     | 300                      | C, M        | +5             | 3-State | Separate               | 16           | 290                       | 42                      |
| Am91L02C    | 1024 x 1     | 300                      | C, M        | +5             | 3-State | Separate               | 16           | 173                       | 35                      |
| Am9102D     | 1024 x 1     | 250                      | C           | +5             | 3-State | Separate               | 16           | 290                       | 42                      |
| Am9111A     | 256 x 4      | 500                      | C, M        | +5             | 3-State | Bussed                 | 18           | 290                       | 46                      |
| Am91L11A    | 256 x 4      | 500                      | C, M        | +5             | 3-State | Bussed                 | 18           | 173                       | 37                      |
| Am9111B     | 256 x 4      | 400                      | C, M        | +5             | 3-State | Bussed                 | 18           | 290                       | 46                      |
| Am91L11B    | 256 x 4      | 400                      | C, M        | +5             | 3-State | Bussed                 | 18           | 173                       | 37                      |
| Am9111C     | 256 x 4      | 300                      | C, M        | +5             | 3-State | Bussed                 | 18           | 315                       | 46                      |
| Am91L11C    | 256 x 4      | 300                      | C, M        | +5             | 3-State | Bussed                 | 18           | 189                       | 37                      |
| Am9111D     | 256 x 4      | 250                      | C           | +5             | 3-State | Bussed                 | 18           | 315                       | 46                      |
| Am9112A     | 256 x 4      | 500                      | C, M        | +5             | 3-State | Bussed                 | 16           | 290                       | 46                      |
| Am91L12A    | 256 x 4      | 500                      | C, M        | +5             | 3-State | Bussed                 | 16           | 173                       | 37                      |
| Am9112B     | 256 x 4      | 400                      | C, M        | +5             | 3-State | Bussed                 | 16           | 290                       | 46                      |
| Am91L12B    | 256 x 4      | 400                      | C, M        | +5             | 3-State | Bussed                 | 16           | 173                       | 37                      |
| Am9112C     | 256 x 4      | 300                      | C, M        | +5             | 3-State | Bussed                 | 16           | 315                       | 46                      |
| Am91L12C    | 256 x 4      | 300                      | C, M        | +5             | 3-State | Bussed                 | 16           | 189                       | 37                      |
| Am9112D     | 256 x 4      | 250                      | C           | +5             | 3-State | Bussed                 | 16           | 315                       | 46                      |
| Am9114B     | 1024 x 4     | 450                      | C, M        | +5             | 3-State | Bussed                 | 18           | 367                       |                         |
| Am9114C     | 1024 x 4     | 300                      | C, M        | +5             | 3-State | Bussed                 | 18           | 367                       |                         |
| Am9114E     | 1024 x 4     | 200                      | C           | +5             | 3-State | Bussed                 | 18           | 367                       |                         |
| Am91L14B    | 1024 x 4     | 450                      | C, M        | +5             | 3-State | Bussed                 | 18           | 262                       |                         |
| Am91L14C    | 1024 x 4     | 300                      | C, M        | +5             | 3-State | Bussed                 | 18           | 262                       |                         |
| Am91L14E    | 1024 x 4     | 200                      | C           | +5             | 3-State | Bussed                 | 18           | 262                       |                         |
| Am9124B     | 1024 x 4     | 450                      | C, M        | +5             | 3-State | Bussed                 | 18           | 367                       | 157                     |
| Am9124C     | 1024 x 4     | 300                      | C, M        | +5             | 3-State | Bussed                 | 18           | 367                       | 157                     |
| Am9124E     | 1024 x 4     | 200                      | C           | +5             | 3-State | Bussed                 | 18           | 367                       | 157                     |
| Am91L24B    | 1024 x 4     | 450                      | C, M        | +5             | 3-State | Bussed                 | 18           | 262                       | 105                     |
| Am91L24C    | 1024 x 4     | 300                      | C, M        | +5             | 3-State | Bussed                 | 18           | 262                       | 105                     |
| Am91L24E    | 1024 x 4     | 200                      | C           | +5             | 3-State | Bussed                 | 18           | 262                       | 105                     |
| Am9130A     | 1024 x 4     | 500                      | C, M        | +5             | 3-State | Bussed                 | 22           | 578                       | 84                      |
| Am9130B     | 1024 x 4     | 400                      | C, M        | +5             | 3-State | Bussed                 | 22           | 578                       | 84                      |
| Am9130C     | 1024 x 4     | 300                      | C, M        | +5             | 3-State | Bussed                 | 22           | 578                       | 84                      |
| Am9130D     | 1024 x 4     | 250                      | C           | +5             | 3-State | Bussed                 | 22           | 578                       | 84                      |
| Am9130E     | 1024 x 4     | 200                      | C           | +5             | 3-State | Bussed                 | 22           | 578                       | 84                      |
| Am91L30A    | 1024 x 4     | 500                      | C, M        | +5             | 3-State | Bussed                 | 22           | 367                       | 72                      |
| Am91L30B    | 1024 x 4     | 400                      | C, M        | +5             | 3-State | Bussed                 | 22           | 367                       | 72                      |
| Am91L30C    | 1024 x 4     | 300                      | C, M        | +5             | 3-State | Bussed                 | 22           | 367                       | 72                      |
| Am91L30D    | 1024 x 4     | 250                      | C           | +5             | 3-State | Bussed                 | 22           | 367                       | 72                      |
| Am9131A     | 1024 x 4     | 500                      | C, M        | +5             | 3-State | Bussed                 | 22           | 578                       | 84                      |
| Am9131B     | 1024 x 4     | 400                      | C, M        | +5             | 3-State | Bussed                 | 22           | 578                       | 84                      |
| Am9131C     | 1024 x 4     | 300                      | C, M        | +5             | 3-State | Bussed                 | 22           | 578                       | 84                      |
| Am9131D     | 1024 x 4     | 250                      | C           | +5             | 3-State | Bussed                 | 22           | 578                       | 84                      |
| Am9131E     | 1024 x 4     | 200                      | C           | +5             | 3-State | Bussed                 | 22           | 578                       | 84                      |
| Am91L31A    | 1024 x 4     | 500                      | C, M        | +5             | 3-State | Bussed                 | 22           | 367                       | 72                      |
| Am91L31B    | 1024 x 4     | 400                      | C, M        | +5             | 3-State | Bussed                 | 22           | 367                       | 72                      |
| Am91L31C    | 1024 x 4     | 300                      | C, M        | +5             | 3-State | Bussed                 | 22           | 367                       | 72                      |
| Am91L31D    | 1024 x 4     | 250                      | C           | +5             | 3-State | Bussed                 | 22           | 367                       | 72                      |
| Am9140A     | 4096 x 1     | 500                      | C, M        | +5             | 3-State | Separate               | 22           | 578                       | 84                      |
| Am9140B     | 4096 x 1     | 400                      | C, M        | +5             | 3-State | Separate               | 22           | 578                       | 84                      |
| Am9140C     | 4096 x 1     | 300                      | C, M        | +5             | 3-State | Separate               | 22           | 578                       | 84                      |
| Am9140D     | 4096 x 1     | 250                      | C           | +5             | 3-State | Separate               | 22           | 578                       | 84                      |
| Am9140E     | 4096 x 1     | 200                      | C           | +5             | 3-State | Separate               | 22           | 578                       | 84                      |
| Am91L40A    | 4096 x 1     | 500                      | C, M        | +5             | 3-State | Separate               | 22           | 367                       | 72                      |
| Am91L40B    | 4096 x 1     | 400                      | C, M        | +5             | 3-State | Separate               | 22           | 367                       | 72                      |
| Am91L40C    | 4096 x 1     | 300                      | C, M        | +5             | 3-State | Separate               | 22           | 367                       | 72                      |
| Am91L40D    | 4096 x 1     | 250                      | C           | +5             | 3-State | Separate               | 22           | 367                       | 72                      |
| Am9141A     | 4096 x 1     | 500                      | C, M        | +5             | 3-State | Separate               | 22           | 578                       | 84                      |
| Am9141B     | 4096 x 1     | 400                      | C, M        | +5             | 3-State | Separate               | 22           | 578                       | 84                      |

# MOS MEMORY SELECTION GUIDE

## STATIC R/W RANDOM-ACCESS MEMORIES

| Part Number | Organization | Maximum Access Time (ns) | Temp. Range | Supply Voltage | Outputs | Data I/O Configuration | Package Pins | Operating Power Max (mW) | Standby Power Max (mW) |
|-------------|--------------|--------------------------|-------------|----------------|---------|------------------------|--------------|--------------------------|------------------------|
| Am9141C     | 4096 x 1     | 300                      | C, M        | +5             | 3-State | Separate               | 22           | 578                      | 84                     |
| Am9141D     | 4096 x 1     | 250                      | C           | +5             | 3-State | Separate               | 22           | 578                      | 84                     |
| Am9141E     | 4096 x 1     | 200                      | C           | +5             | 3-State | Separate               | 22           | 578                      | 84                     |
| Am91L41A    | 4096 x 1     | 500                      | C, M        | +5             | 3-State | Separate               | 22           | 367                      | 72                     |
| Am91L41B    | 4096 x 1     | 400                      | C, M        | +5             | 3-State | Separate               | 22           | 367                      | 72                     |
| Am91L41C    | 4096 x 1     | 300                      | C, M        | +5             | 3-State | Separate               | 22           | 367                      | 72                     |
| Am91L41D    | 4096 x 1     | 250                      | C           | +5             | 3-State | Separate               | 22           | 367                      | 72                     |
| Am9044B     | 4096 x 1     | 450                      | C, M        | +5             | 3-State | Separate               | 18           | 385                      |                        |
| Am9044C     | 4096 x 1     | 300                      | C, M        | +5             | 3-State | Separate               | 18           | 385                      |                        |
| Am9044D     | 4096 x 1     | 250                      | C, M        | +5             | 3-State | Separate               | 18           | 385                      |                        |
| Am9044E     | 4096 x 1     | 200                      | C           | +5             | 3-State | Separate               | 18           | 385                      |                        |
| Am9244B     | 4096 x 1     | 450                      | C, M        | +5             | 3-State | Separate               | 18           | 385                      | 165                    |
| Am9244C     | 4096 x 1     | 300                      | C, M        | +5             | 3-State | Separate               | 18           | 385                      | 165                    |
| Am9244D     | 4096 x 1     | 250                      | C, M        | +5             | 3-State | Separate               | 18           | 385                      | 165                    |
| Am9244E     | 4096 x 1     | 200                      | C           | +5             | 3-State | Separate               | 18           | 385                      | 165                    |
| Am90L44B    | 4096 x 1     | 450                      | C, M        | +5             | 3-State | Separate               | 18           | 275                      |                        |
| Am90L44C    | 4096 x 1     | 300                      | C, M        | +5             | 3-State | Separate               | 18           | 275                      |                        |
| Am90L44D    | 4096 x 1     | 250                      | C           | +5             | 3-State | Separate               | 18           | 275                      |                        |
| Am92L44B    | 4096 x 1     | 450                      | C, M        | +5             | 3-State | Separate               | 18           | 275                      | 110                    |
| Am92L44C    | 4096 x 1     | 300                      | C, M        | +5             | 3-State | Separate               | 18           | 275                      | 110                    |
| Am92L44D    | 4096 x 1     | 250                      | C           | +5             | 3-State | Separate               | 18           | 275                      | 110                    |
| Am9147-70   | 4096 x 1     | 70                       | C, M        | +5             | 3-State | Separate               | 18           | 990                      | 165                    |
| Am9147-55   | 4096 x 1     | 55                       | C           | +5             | 3-State | Separate               | 18           | 990                      | 165                    |

ΔAutomatic power down with chip select.

## DYNAMIC R/W RANDOM-ACCESS MEMORIES

| Part Number | Organization | Maximum Access Time (ns) | Temp. Range | Supply Voltages | Operating Power (mW) | Outputs    | Data I/O Configuration | Package Pins | Refresh Time (ns) | Standby Power-Max. (mW) |
|-------------|--------------|--------------------------|-------------|-----------------|----------------------|------------|------------------------|--------------|-------------------|-------------------------|
| Am9050C     | 4096 x 1     | 300                      | C           | -5, +12         | 750                  | Open Drain | Bussed                 | 18           | 2.0               | 3.0                     |
| Am9050D     | 4096 x 1     | 250                      | C           | -5, +12         | 750                  | Open Drain | Bussed                 | 18           | 2.0               | 3.0                     |
| Am9050E     | 4096 x 1     | 200                      | C           | -5, +12         | 750                  | Open Drain | Bussed                 | 18           | 2.0               | 3.0                     |
| Am9060C     | 4096 x 1     | 300                      | C           | ±5, +12         | 750                  | 3-State    | Separate               | 22           | 2.0               | 3.0                     |
| Am9060D     | 4096 x 1     | 250                      | C           | ±5, +12         | 750                  | 3-State    | Separate               | 22           | 2.0               | 3.0                     |
| Am9060E     | 4096 x 1     | 200                      | C           | ±5, +12         | 750                  | 3-State    | Separate               | 22           | 2.0               | 3.0                     |
| Am90L50C    | 4096 x 1     | 300                      | C           | -5, +12         | 396                  | Open Drain | Bussed                 | 18           | 2.0               | 3.0                     |
| Am90L50D    | 4096 x 1     | 250                      | C           | -5, +12         | 396                  | Open Drain | Bussed                 | 18           | 2.0               | 3.0                     |
| Am90L50E    | 4096 x 1     | 200                      | C           | -5, +12         | 396                  | Open Drain | Bussed                 | 18           | 2.0               | 3.0                     |
| Am90L60C    | 4096 x 1     | 300                      | C           | ±5, +12         | 396                  | 3-State    | Separate               | 22           | 2.0               | 3.0                     |
| Am90L60D    | 4096 x 1     | 250                      | C           | ±5, +12         | 396                  | 3-State    | Separate               | 22           | 2.0               | 3.0                     |
| Am90L60E    | 4096 x 1     | 200                      | C           | ±5, +12         | 396                  | 3-State    | Separate               | 22           | 2.0               | 3.0                     |
| Am9016C     | 16384 x 1    | 300                      | C           | ±5, +12         | 480                  | 3-State    | Separate               | 16           | 2.0               | 20.0                    |
| Am9016D     | 16384 x 1    | 250                      | C           | ±5, +12         | 480                  | 3-State    | Separate               | 16           | 2.0               | 20.0                    |
| Am9016E     | 16384 x 1    | 200                      | C           | ±5, +12         | 480                  | 3-State    | Separate               | 16           | 2.0               | 20.0                    |
| Am9016F     | 16384 x 1    | 150                      | C           | ±5, +12         | 480                  | 3-State    | Separate               | 16           | 2.0               | 20.0                    |

## READ-ONLY MEMORIES

| Part Number | Organization | Access Time (ns) | Temp. Range | Supply Voltages | Operating Power—Max. (mW) | Outputs |
|-------------|--------------|------------------|-------------|-----------------|---------------------------|---------|
| C8316A      | 2048 x 8     | 850              | C           | +5              | 514                       | 3-State |
| C8316E      | 2048 x 8     | 450              | C           | +5              | 499                       | 3-State |
| Am9208B     | 1024 x 8     | 400              | C, M        | +5, +12         | 620                       | 3-State |
| Am9208C     | 1024 x 8     | 300              | C, M        | +5, +12         | 620                       | 3-State |
| Am9208D     | 1024 x 8     | 250              | C           | +5, +12         | 700                       | 3-State |
| Am9214      | 512 x 8      | 500              | C, M        | +5              | 263                       | 3-State |
| Am9216B     | 2048 x 8     | 400              | C, M        | +5, +12         | 660                       | 3-State |
| Am9216C     | 2048 x 8     | 300              | C           | +5, +12         | 700                       | 3-State |
| Am9217A     | 2048 x 8     | 550              | C, M        | +5              | 367                       | 3-State |
| Am9217B     | 2048 x 8     | 450              | C, M        | +5              | 367                       | 3-State |
| Am9218B     | 2048 x 8     | 450              | C, M        | +5              | 367                       | 3-State |
| Am9218C     | 2048 x 8     | 350              | C           | +5              | 367                       | 3-State |
| Am9232      | 4096 x 8     | 350              | C, M        | +5              | 500                       | 3-State |

# MOS MEMORY SELECTION GUIDE

## ERASABLE PROGRAMMABLE READ-ONLY MEMORY

| Part Number | Organization | Access Time (nsec) | Temp. Range | Supply Voltages | Operating Power – Max. (mW) | Outputs |
|-------------|--------------|--------------------|-------------|-----------------|-----------------------------|---------|
| Am1702A     | 256 x 8      | 1000               | C, E        | -9V, +5V        | 676                         | 3-State |
| Am1702A-1   | 256 x 8      | 550                | C, E        | -9V, +5V        | 676                         | 3-State |
| Am1702A-2   | 256 x 8      | 650                | C, E        | -9V, +5V        | 676                         | 3-State |
| Am1702AL    | 256 x 8      | 1000               | C, E        | -9V, +5V        | -                           | 3-State |
| Am1702AL-1  | 256 x 8      | 550                | C, E        | -9V, +5V        | -                           | 3-State |
| Am1702AL-2  | 256 x 8      | 650                | C, E        | -9V, +5V        | -                           | 3-State |
| Am2708      | 1024 x 8     | 450                | C, M        | +5V, +12V, -5V  | 800                         | 3-State |
| **Am2716    | 2048 x 8     | 450                | C, E        | +5V, +12V, -5V  | -                           | 3-State |
| ****Am2732  | 4192 x 8     | 450                | C           | +5V             | -                           | 3-State |

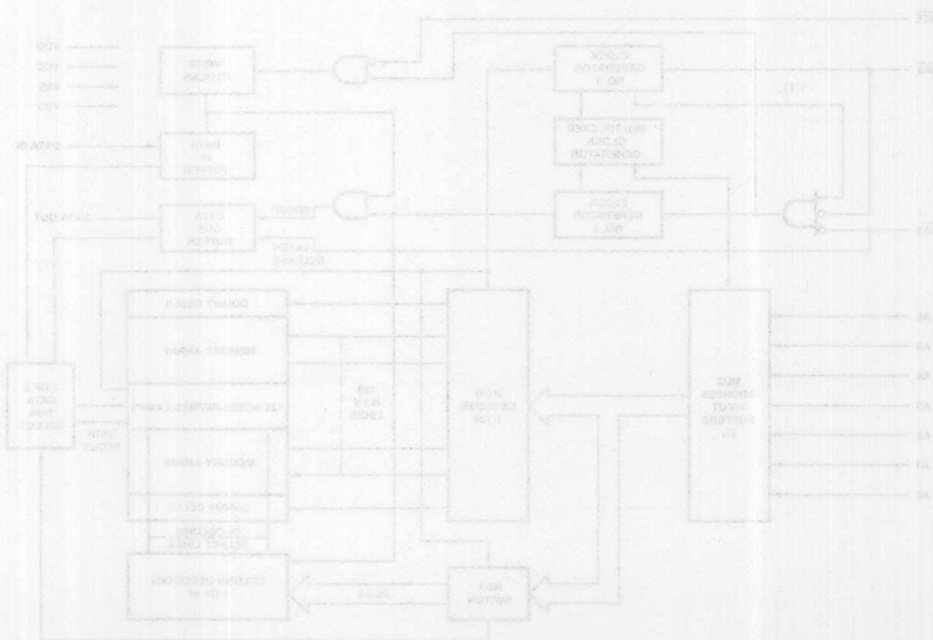
The three-state output buffer turns on when the output enable time has elapsed and turns off after CAS goes high, and output data are the same polarity.

Am1702A, including the two clocks, are TTL compatible. The Row Address Strobe (RAS) loads the row address and the Column Address Strobe (CAS) loads the column address. The row and column address signals share 3 input lines. Address cycles are initiated when RAS goes low and standby mode is entered when RAS goes high. In addition to normal read and write cycles, other types of operations are available in burst mode, including performance and power dissipation.

charge on a small capacitor. This mechanism requires no refreshing of the memory cells to maintain stored information.

- High speed operation – 180ns access, 250ns cycle
- 100% tolerance on standard +12V, -5V
- TTL compatible interface signals
- Tri-state output
- RAS only, RAS and Page mode clocking options
- 128 cycle refreshing
- Latched data output
- Standard 18-pin, 3 inch wide-bus in-line package
- Double poly N-channel silicon gate MOS technology
- 100% MIL-STD-883C reliability assurance testing

### BLOCK DIAGRAM



### ORDERING INFORMATION

| Access Time | Package Type | Temperature  |
|-------------|--------------|--------------|
| 180ns       | Am1702A-1C   | 0°C to +70°C |
| 550ns       | Am1702A-1C   | 0°C to +70°C |
| 650ns       | Am1702A-1C   | 0°C to +70°C |
| 1000ns      | Am1702A-1C   | 0°C to +70°C |

## DISTINCTIVE CHARACTERISTICS

- High density 16k x 1 organization
- Direct replacement for MK4116
- Low maximum power dissipation — 462mW active, 20mW standby
- High speed operation — 150ns access, 320ns cycle
- $\pm 10\%$  tolerance on standard +12, +5, -5 voltages
- TTL compatible interface signals
- Three-state output
- RAS only, RMW and Page mode clocking options
- 128 cycle refreshing
- Unlatched data output
- Standard 16-pin, .3 inch wide dual in-line package
- Double poly N-channel silicon gate MOS technology
- 100% MIL-STD-883 reliability assurance testing

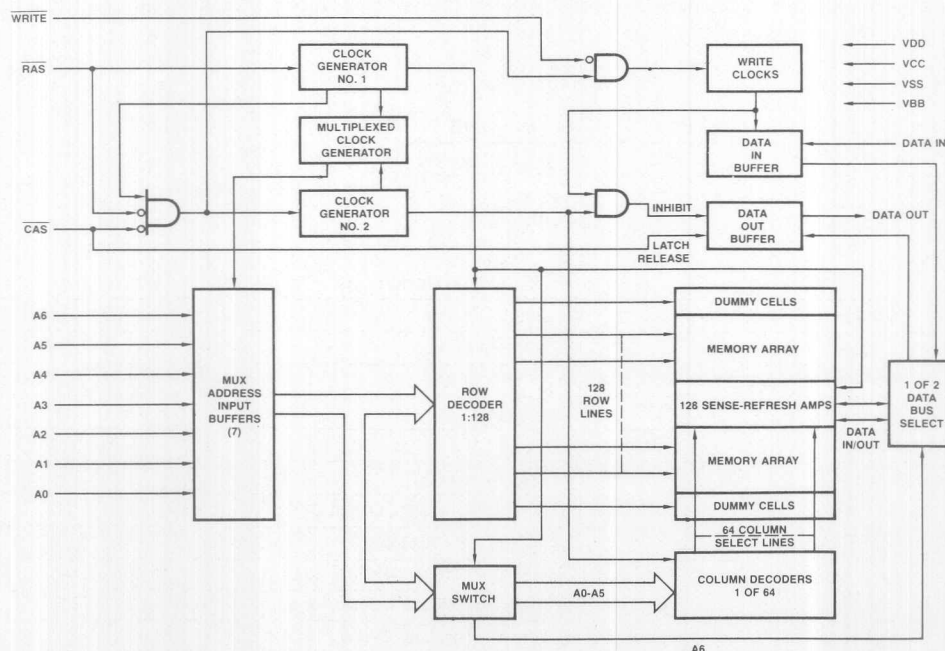
## GENERAL DESCRIPTION

The Am9016 is a high speed, 16k-bit, dynamic, read/write random access memory. It is organized as 16,384 words by 1 bit per word and is packaged in a standard 16-pin DIP. The basic memory element is a single transistor cell that stores charge on a small capacitor. This mechanism requires periodic refreshing of the memory cells to maintain stored information.

All input signals, including the two clocks, are TTL compatible. The Row Address Strobe (RAS) loads the row address and the Column Address Strobe (CAS) loads the column address. The row and column address signals share 7 input lines. Active cycles are initiated when  $\overline{\text{RAS}}$  goes low, and standby mode is entered when  $\overline{\text{RAS}}$  goes high. In addition to normal read and write cycles, other types of operations are available to improve versatility, performance, and power dissipation.

The three-state output buffer turns on when the column access time has elapsed and turns off after CAS goes high. Input and output data are the same polarity.

## BLOCK DIAGRAM



A6

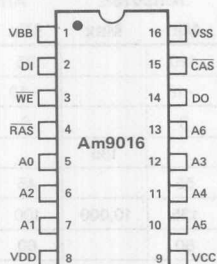
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## ORDERING INFORMATION

| Ambient Temperature                                   | Package Type | Access Time |           |           |           |
|---|--------------|-------------|-----------|-----------|-----------|
|   |              | 300ns       | 250ns     | 200ns     | 150ns     |
| $0^{\circ}\text{C} \leq T_A \leq +70^{\circ}\text{C}$ | Hermetic DIP | AM9016CDC   | AM9016DDC | AM9016EDC | AM9016FDC |
|   | Molded DIP   | AM9016CPC   | AM9016DPC | AM9016EPC | AM9016FPC |



## CONNECTION DIAGRAM



Top View  
Pin 1 is marked for orientation.

|         |                       |
|---------|-----------------------|
| A0 – A6 | ADDRESS INPUTS        |
| CAS     | COLUMN ADDRESS STROBE |
| DI      | DATA IN               |
| DO      | DATA OUT              |
| RAS     | ROW ADDRESS STROBE    |
| VDD     | POWER (+12V)          |
| VCC     | POWER (+5V)           |
| VSS     | GROUND                |
| VBB     | POWER (–5V)           |
| WE      | WRITE ENABLE          |

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**MAXIMUM RATINGS** beyond which useful life may be impaired

|   |                 |
|---|-----------------|
| Storage Temperature                             | –65°C to +150°C |
| Ambient Temperature Under Bias                  | 0°C to +70°C    |
| Voltage on Any Pin Relative to VBB              | –0.5V to +20V   |
| VDD and VCC Supply Voltages with Respect to VSS | –1.0V to +15.0V |
| VBB – VSS (VDD – VSS > 0V)                      | 0V              |
| Power Dissipation                               | 1.0W            |
| Short Circuit Output Current                    | 50mA            |

The products described by this specification include internal circuitry designed to protect input devices from damaging accumulation of static charge. It is suggested nevertheless, that conventional precautions be observed during storage, handling, and use in order to avoid exposure to excessive voltages.

**OPERATING RANGE**

| Ambient Temperature          | VDD       | VCC      | VSS | VBB        |
|------------------------------|-----------|----------|-----|------------|
| 0°C ≤ T <sub>A</sub> ≤ +70°C | +12V ±10% | +5V ±10% | 0   | –5.0V ±10% |

**ELECTRICAL CHARACTERISTICS** over operating range (Notes 1, 11)

|            |   | Am9016X  |      |      |      |       |
|------------|---|--|------|------|------|-------|
| Parameters | Description                             | Test Conditions  | Min. | Typ. | Max. | Units |
| VOH        | Output HIGH Voltage                     | IOH = –5.0mA   | 2.4  |      | VCC  | Volts |
| VOL        | Output LOW Voltage                      | IOL = 4.2mA  | VSS  |      | 0.40 | Volts |
| VIH        | Input HIGH Voltage for Address, Data In |  | 2.4  |      | 7.0  | Volts |
| VIHC       | Input HIGH Voltage for CAS, RAS, WE     |  | 2.7  |      | 7.0  | Volts |
| VIL        | Input LOW Voltage                       |  | –1.0 |      | 0.80 | Volts |
| IIX        | Input Load Current                      | VSS ≤ VI ≤ 7V  | –10  |      | 10   | μA    |
| IOZ        | Output Leakage Current                  | VSS ≤ VO ≤ VCC, Output OFF                                   | –10  |      | 10   | μA    |
| ICC        | VCC Supply Current                      | Output OFF (Note 4)  | –10  |      | 10   | μA    |
| IBB        | VBB Supply Current, Average             | Standby, RAS ≥ VIH   |      |      | 100  | μA    |
|            |   | Operating, Minimum Cycle Time                                |      |      | 200  |       |
| IDD        | VDD Supply Current, Average             | Operating IDD1 RAS Cycling, CAS Cycling, Minimum Cycle Times |      |      | 35   | mA    |
|            |   | Page Mode IDD4 RAS ≤ VIL, CAS Cycling, Minimum Cycle Times   |      |      | 27   |       |
|            |   | Refresh IDD3 RAS Cycling, CAS ≥ VIH, Minimum Cycle Times     |      |      | 27   |       |
|            |   | Standby IDD2 RAS ≥ VIH                                       |      |      | 1.5  |       |
| CI         | Input Capacitance                       | RAS, CAS, WE   |      |      | 10   | pF    |
|            |   | Address, Data In   |      |      | 5.0  |       |
| CO         | Output Capacitance                      | Output OFF   |      |      | 7.0  |       |

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**SWITCHING CHARACTERISTICS** over operating range (Notes 2, 3, 5, 10)

| Parameters | Description  | Am9016C |        | Am9016D |        | Am9016E |        | Am9016F |        | Units |
|------------|--|---------|--------|---------|--------|---------|--------|---------|--------|-------|
|            |  | Min     | Max    | Min     | Max    | Min     | Max    | Min     | Max    |       |
| tAR        | RAS LOW to Column Address Hold Time  | 200     |        | 160     |        | 120     |        | 95      |        | ns    |
| tASC       | Column Address Set-up Time   | -10     |        | -10     |        | -10     |        | -10     |        | ns    |
| tASR       | Row Address Set-up Time  | 0       |        | 0       |        | 0       |        | 0       |        | ns    |
| tCAC       | Access Time from $\overline{\text{CAS}}$ (Note 6)                            |         | 185    |         | 165    |         | 135    |         | 100    | ns    |
| tCAH       | CAS LOW to Column Address Hold Time  | 85      |        | 75      |        | 55      |        | 45      |        | ns    |
| tCAS       | CAS Pulse Width  | 185     | 10,000 | 165     | 10,000 | 135     | 10,000 | 100     | 10,000 | ns    |
| tCP        | Page Mode CAS Precharge Time   | 100     |        | 100     |        | 80      |        | 60      |        | ns    |
| tCRP       | CAS to RAS Precharge Time  | -20     |        | -20     |        | -20     |        | -20     |        | ns    |
| tCSH       | CAS Hold Time  | 300     |        | 250     |        | 200     |        | 150     |        | ns    |
| tCWD       | CAS LOW to $\overline{\text{WE}}$ LOW Delay (Note 9)                         | 145     |        | 125     |        | 95      |        | 70      |        | ns    |
| tCWL       | $\overline{\text{WE}}$ LOW to CAS HIGH Set-up Time                           | 100     |        | 85      |        | 70      |        | 50      |        | ns    |
| tDH        | CAS LOW or $\overline{\text{WE}}$ LOW to Data In Valid Hold Time (Note 7)    | 85      |        | 75      |        | 55      |        | 45      |        | ns    |
| tDHR       | RAS LOW to Data In Valid Hold Time   | 200     |        | 160     |        | 120     |        | 95      |        | ns    |
| tDS        | Data In Stable to CAS LOW or $\overline{\text{WE}}$ LOW Set-up Time (Note 7) | 0       |        | 0       |        | 0       |        | 0       |        | ns    |
| tOFF       | CAS HIGH to Output OFF Delay   | 0       | 60     | 0       | 60     | 0       | 50     | 0       | 40     | ns    |
| tPC        | Page Mode Cycle Time   | 295     |        | 275     |        | 225     |        | 170     |        | ns    |
| tRAC       | Access Time from RAS (Note 6)  |         | 300    |         | 250    |         | 200    |         | 150    | ns    |
| tRAH       | RAS LOW to Row Address Hold Time   | 45      |        | 35      |        | 25      |        | 20      |        | ns    |
| tRAS       | RAS Pulse Width  | 300     | 10,000 | 250     | 10,000 | 200     | 10,000 | 150     | 10,000 | ns    |
| tRC        | Random Read or Write Cycle Time  | 460     |        | 410     |        | 375     |        | 320     |        | ns    |
| tRCD       | RAS LOW to $\overline{\text{CAS}}$ LOW Delay (Note 6)                        | 35      | 115    | 35      | 85     | 25      | 65     | 20      | 50     | ns    |
| tRCH       | Read Hold Time   | 0       |        | 0       |        | 0       |        | 0       |        | ns    |
| tRCS       | Read Set-up Time   | 0       |        | 0       |        | 0       |        | 0       |        | ns    |
| tREF       | Refresh Interval   |         | 2      |         | 2      |         | 2      |         | 2      | ms    |
| tRMW       | Read Modify Write Cycle Time   | 600     |        | 500     |        | 405     |        | 320     |        | ns    |
| tRP        | RAS Precharge Time   | 150     |        | 150     |        | 120     |        | 100     |        | ns    |
| tRSH       | CAS LOW to RAS HIGH Delay  | 185     |        | 165     |        | 135     |        | 100     |        | ns    |
| tRWC       | Read/Write Cycle Time  | 525     |        | 425     |        | 375     |        | 320     |        | ns    |
| tRWD       | RAS LOW to $\overline{\text{WE}}$ LOW Delay (Note 9)                         | 260     |        | 210     |        | 160     |        | 120     |        | ns    |
| tRWL       | $\overline{\text{WE}}$ LOW to RAS HIGH Set-up Time                           | 100     |        | 85      |        | 70      |        | 50      |        | ns    |
| tT         | Transition Time  | 3       | 50     | 3       | 50     | 3       | 50     | 3       | 35     | ns    |
| tWCH       | Write Hold Time  | 85      |        | 75      |        | 55      |        | 45      |        | ns    |
| tWCR       | RAS LOW to Write Hold Time   | 200     |        | 160     |        | 120     |        | 95      |        | ns    |
| tWCS       | $\overline{\text{WE}}$ LOW to CAS LOW Set-up Time (Note 9)                   | -20     |        | -20     |        | -20     |        | -20     |        | ns    |
| tWP        | Write Pulse Width  | 85      |        | 75      |        | 55      |        | 45      |        | ns    |

**NOTES**

- Typical values are for  $T_A = 25^\circ\text{C}$ , nominal supply voltages and nominal processing parameters.
- Signal transition times are assumed to be 5ns. Transition times are measured between specified high and low logic levels.
- Timing reference levels for both input and output signals are the specified worst-case logic levels.
- VCC is used in the output buffer only. ICC will therefore depend only on leakage current and output loading. When the output is ON and at a logic high level, VCC is connected to the Data Out pin through an equivalent resistance of approximately 135 $\Omega$ . In standby mode VCC may be reduced to zero without affecting stored data or refresh operations.
- Output loading is two standard TTL loads plus 100pF capacitance.
- Both RAS and CAS must be low to read data. Access timing will depend on the relative positions of their falling edges. When tRCD is less than the maximum value shown, access time depends on RAS and tRAC governs. When tRCD is more than the maximum value shown access time depends on  $\overline{\text{CAS}}$  and tCAC governs. The

maximum value listed for tRCD is shown for reference purposes only and does not restrict operation of the part.

- Timing reference points for data input set-up and hold times will depend on what type of write cycle is being performed and will be the later falling edge of CAS or WE.
- At least eight initialization cycles that exercise  $\overline{\text{RAS}}$  should be performed after power-up and before valid operations are begun.
- The tWCS, tRWD and tCWD parameters are shown for reference purposes only and do not restrict the operating flexibility of the part. When the falling edge of WE follows the falling edge of CAS by at most tWCS, the data output buffer will remain off for the whole cycle and an "early write" cycle is defined. When the falling edge of WE follows the falling edges of RAS and  $\overline{\text{CAS}}$  by at least tRWD and tCWD respectively, the Data Out from the addressed cell will be valid at the access time and a "read/write" cycle is defined. The falling edge of WE may also occur at intermediate positions, but the condition and validity of the Data Out signal will not be known.
- Switching characteristics are listed in alphabetical order.
- All voltages referenced to VSS.

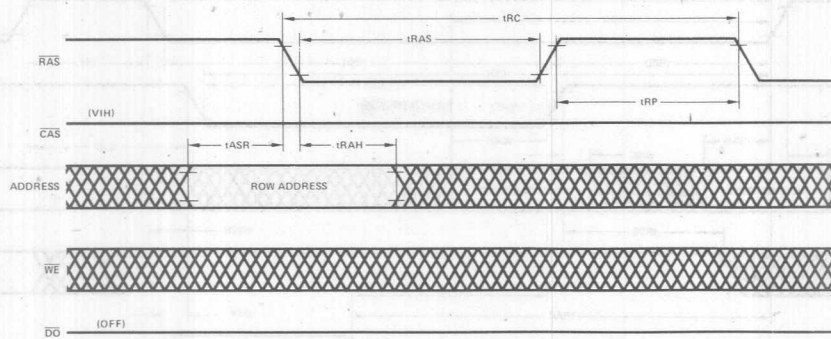
## READ CYCLE



## MOS-193

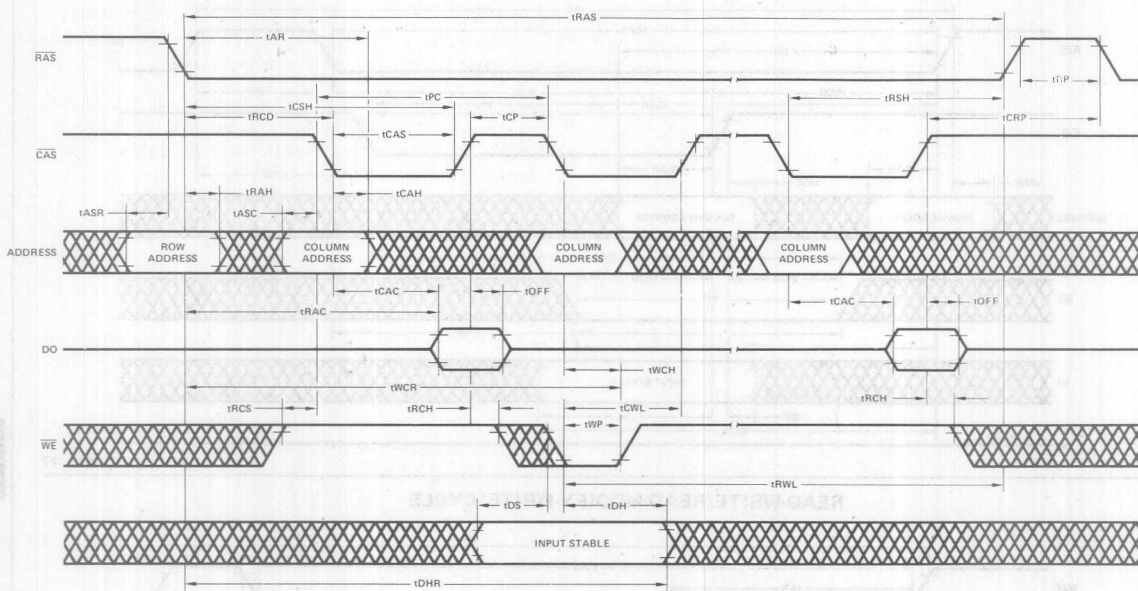
## MOS-194

**RAS ONLY REFRESH CYCLE**



MOS-195

## PAGE MODE CYCLE



MOS-196

## APPLICATION INFORMATION

The Am9016 electrical connections are such that if power is applied with the device installed upside down it will be permanently damaged. Precautions should be taken to avoid this mishap.

## OPERATING CYCLES

Random read operations from any location hold the  $\overline{WE}$  line high and follow this sequence of events:

- 1) The row address is applied to the address inputs and  $\overline{RAS}$  is switched low.
- 2) After the row address hold time has elapsed, the column address is applied to the address inputs and  $\overline{CAS}$  is switched low.
- 3) Following the access time, the output will turn on and valid read data will be present. The data will remain valid as long as  $\overline{CAS}$  is low.
- 4)  $\overline{CAS}$  and  $\overline{RAS}$  are then switched high to end the operation. A new cycle cannot begin until the precharge period has elapsed.

Random write operations follow the same sequence of events, except that the  $\overline{WE}$  line is low for some portion of the cycle. If the data to be written is available early in the cycle, it will usually be convenient to simply have  $\overline{WE}$  low for the whole write operation.

Sequential Read and Write operations at the same location can be designed to save time because re-addressing is not necessary. A read/write cycle holds  $\overline{WE}$  high until a valid read is established and then strobes new data in with the falling edge of  $\overline{WE}$ .

After the power is first applied to the device, the internal circuit requires execution of at least eight initialization cycles which exercise  $\overline{RAS}$  before valid memory accesses are begun.

## ADDRESSING

14 address bits are required to select one location out of the 16,384 cells in the memory. Two groups of 7 bits each are multiplexed onto the 7 address lines and latched into the internal address registers. Two negative-going external clocks are used to control the multiplexing. The Row Address Strobe ( $\overline{RAS}$ ) enters the row address bits and the Column Address Strobe ( $\overline{CAS}$ ) enters the column address bits.

When  $\overline{RAS}$  is inactive, the memory enters its low power standby mode. Once the row address has been latched, it need not be changed for successive operations within the same row, allowing high-speed page-mode operations.

Page-mode operations first establish the row address and then maintain  $\overline{RAS}$  low while  $\overline{CAS}$  is repetitively cycled and designated operations are performed. Any column address within the selected row may be accessed in any sequence. The maximum time that  $\overline{RAS}$  can remain low is the factor limiting the number of page-mode operations that can be performed.

Multiplexed addressing does not introduce extra delays in the access path. By inserting the row address first and the column address second, the memory takes advantage of the fact that the delay path through the memory is shorter for column addresses. The column address does not propagate through the cell matrix as the row address does and it can therefore arrive somewhat later than the row address without impacting the access time.

## REFRESH

The Am9016 is a dynamic memory and each cell must be refreshed at least once every refresh interval in order to maintain the cell contents. Any operation that accesses a row serves to refresh all 128 cells in the row. Thus the refresh requirement is met by accessing all 128 rows at least once every refresh interval. This may be accomplished, in some applications, in the course of performing normal operations. Alternatively, special refresh operations may be initiated. These special operations could be simply additional conventional accesses or they could be " $\overline{RAS}$ -only" cycles. Since only the rows need to be addressed,  $\overline{CAS}$  may be held high while  $\overline{RAS}$  is cycled and the appropriate row addresses are input. Power required for refreshing is minimized and simplified control circuitry will often be possible.

## DATA INPUT/OUTPUT

Data is written into a selected cell by the combination of  $\overline{WE}$  and  $\overline{CAS}$  while  $\overline{RAS}$  is low. The later negative transition of  $\overline{WE}$  or  $\overline{CAS}$  strobes the data into the internal register. In a write cycle, if the  $\overline{WE}$  input is brought low prior to  $\overline{CAS}$ , the data is strobed by  $\overline{CAS}$ , and the set-up and hold times are referenced to  $\overline{CAS}$ . If the cycle is a read/write cycle then the data set-up and hold times are referenced to the negative edge of  $\overline{WE}$ .

In the read cycle the data is read by maintaining  $\overline{WE}$  in the high state throughout the portion of the memory cycle in which  $\overline{CAS}$  is low. The selected valid data will appear at the output within the specified access time.

## DATA OUTPUT CONTROL

Any time  $\overline{CAS}$  is high the data output will be off. The output contains either one or zero during read cycle after the access time has elapsed. Data remains valid from the access time until  $\overline{CAS}$  is returned to the high state. The output data is the same polarity as the input data.

The user can control the output state during write operations by controlling the placement of the  $\overline{WE}$  signal. In the "early write" cycle (see note 9) the output is at a high impedance state throughout the entire cycle.

## POWER CONSIDERATIONS

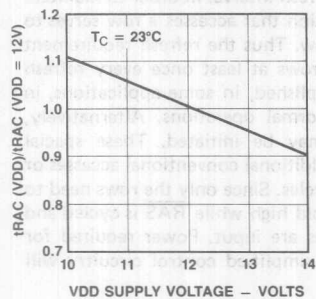
$\overline{RAS}$  and/or  $\overline{CAS}$  can be decoded and used as a chip select signal for the Am9016 but overall system power is minimized if  $\overline{RAS}$  is used for this purpose. The devices which do not receive  $\overline{RAS}$  will be in low power standby mode regardless of the state of  $\overline{CAS}$ .

At all times the Absolute Maximum Rating Conditions must be observed. During power supply sequencing VBB should never be more positive than VSS when power is applied to VDD.

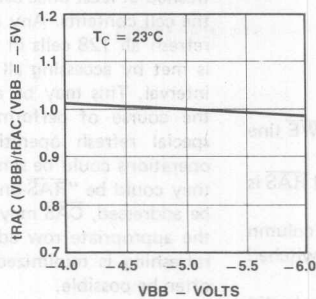


## TYPICAL CHARACTERISTICS

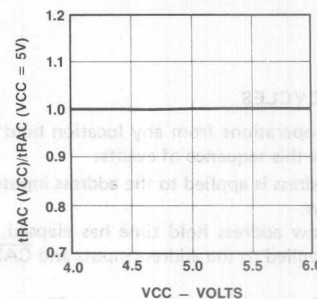
Typical Access Time  
(Normalized)  
 $t_{RAC}$  Versus VDD



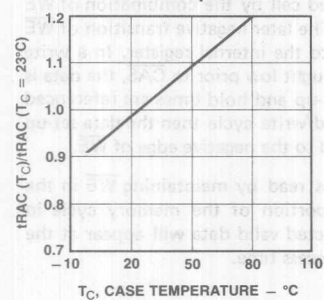
Typical Access Time  
(Normalized)  
 $t_{RAC}$  Versus VBB



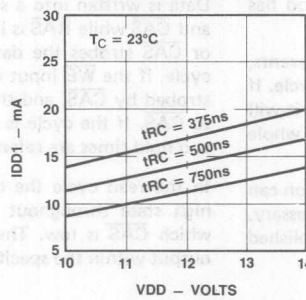
Typical Access Time  
(Normalized)  
 $t_{RAC}$  Versus VCC



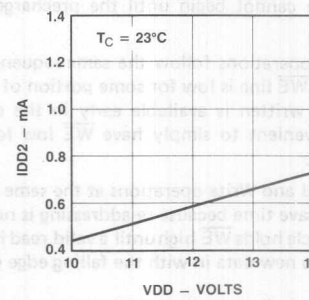
Typical Access Time  
(Normalized)  
 $t_{RAC}$  Versus  
Case Temperature



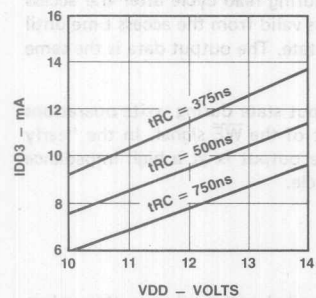
Typical Operating Current  
IDD1 Versus VDD



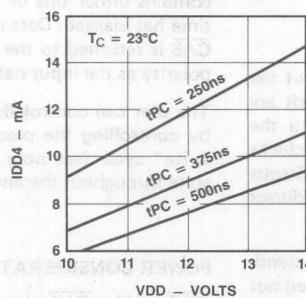
Typical Standby Current  
IDD2 Versus VDD



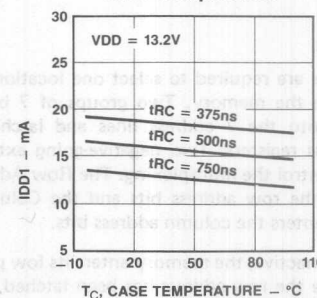
Typical Refresh Current  
IDD3 Versus VDD



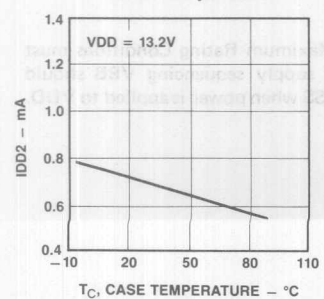
Typical Page Mode  
Current  
IDD4 Versus VDD



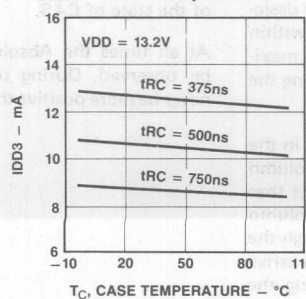
Typical Operating Current  
IDD1 Versus  
Case Temperature



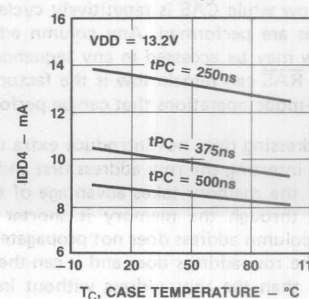
Typical Standby Current  
IDD2 Versus  
Case Temperature



Typical Refresh Current  
IDD3 Versus  
Case Temperature

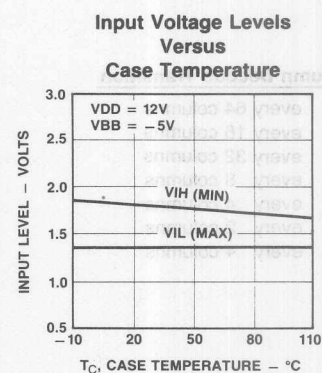
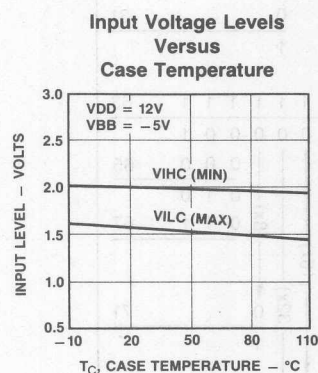
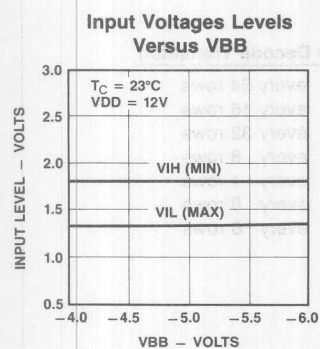
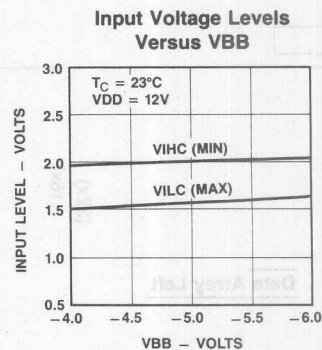
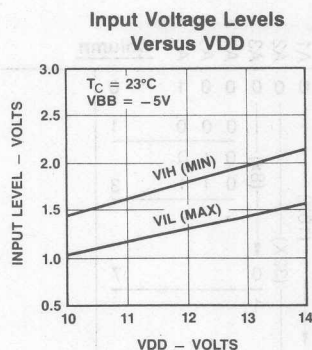
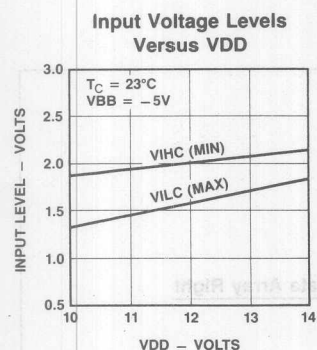


Typical Page Mode Current  
IDD4 Versus  
Case Temperature

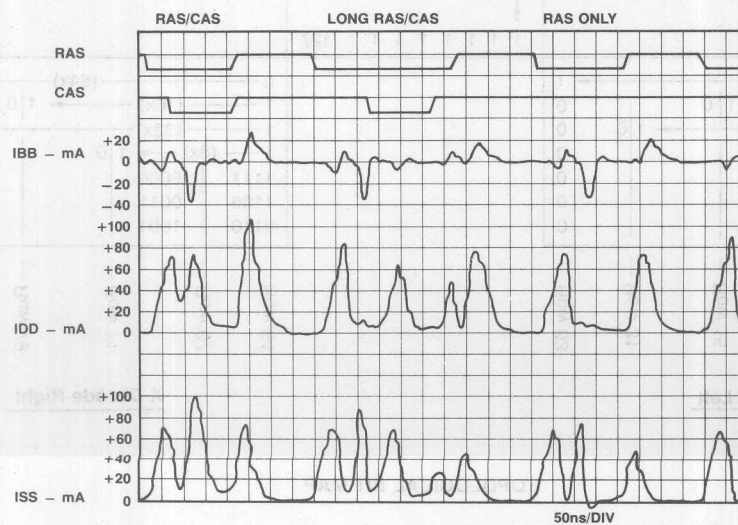




## TYPICAL CHARACTERISTICS (Cont.)



## TYPICAL CURRENT WAVEFORMS



VSS PAD ☐

**Data Array Left**

(32x)  
(16x)

**Column Decode Transition**

A0 every 64 columns  
A1 every 16 columns  
A2 every 32 columns  
A3 every 8 columns  
A4 every 4 columns  
A5 every 2 columns  
A6 every 4 columns

**Data Array Right**

**Row Decode Transition**

A0 every 64 rows  
A1 every 16 rows  
A2 every 32 rows  
A3 every 8 rows  
A4 every 4 rows  
A5 every 8 rows  
A6 every 8 rows

| A0 | A1 | A2 | A3 | A4 | A5 | A6 | Column |
|----|----|----|----|----|----|----|--------|
| 0  | 0  | 0  | 0  | 0  | 0  | 1  | 0      |
|    |    |    |    | 0  | 0  | 0  | 1      |
|    |    |    | 0  | 1  | 0  |    |        |
|    |    |    | 0  | 1  | 1  |    | 3      |
|    |    |    |    |    |    |    |        |
|    |    |    |    |    |    |    | 7      |
|    |    |    |    |    |    | 1  |        |
|    |    |    |    |    |    |    | 15     |
|    |    |    |    |    |    |    |        |
|    |    |    |    |    |    | 0  |        |
|    |    |    |    |    |    |    | 31     |
|    |    |    |    |    |    | 1  |        |
|    |    |    |    |    |    |    |        |
|    |    |    |    |    |    |    | 63     |
|    |    |    |    |    |    |    |        |
|    |    |    |    |    |    | 0  | 65     |
|    |    |    |    |    |    | 0  | 67     |
|    |    |    |    |    |    |    |        |
|    |    |    |    |    |    |    | 71     |
|    |    |    |    |    |    | 1  |        |
|    |    |    |    |    |    |    | 79     |
|    |    |    |    |    |    |    |        |
|    |    |    |    |    |    | 0  |        |
|    |    |    |    |    |    | 1  |        |
|    |    |    |    |    |    |    | 95     |
|    |    |    |    |    |    |    |        |
|    |    |    |    |    |    |    | 127    |

|    |      |       |   |       |
|----|------|-------|---|-------|
| A0 | 1    | (64x) | → | 1     |
| A1 | 1    | (16x) | → | 1   0 |
| A2 | 1    | (32x) | → | 1   0 |
| A3 | 1    | (8x)  | → | 1   0 |
| A4 | 1111 | 0000  |   | 0     |
| A5 | 1100 | 0011  |   | 0     |
| A6 | 1001 | 0110  |   | 0     |

Row 0  
Row 3  
Row 7  
Row 15  
Row 31  
Row 63

|      |       |   |       |
|------|-------|---|-------|
| 0    | (64x) | → | 0     |
| 1    | (16x) | → | 1   0 |
| 1    | (32x) | → | 1   0 |
| 1    | (8x)  | → | 1   0 |
| 1111 | 0000  |   | 1     |
| 1100 | 0011  |   | 1     |
| 0110 | 1001  |   | 1     |

Row 64  
Row 67  
Row 71  
Row 79  
Row 95  
Row 127

**X-Decode Left**

**X-Decode Right**

TOPOLOGICAL BIT MAP

6-15

# Am9044 • Am9244

## 4096 x 1 Static R/W Random Access Memory

### DISTINCTIVE CHARACTERISTICS

- **LOW OPERATING POWER (MAX)**  
**Am9044/Am9244** 385mW (70mA)  
**Am90L44/Am92L44** 275mW (50mA)
- **LOW STANDBY POWER (MAX)**  
**Am92L44** 110mW (20mA)
- Access times down to 200ns (max)
- Military temperature range available to 250ns (max)
- Am9044 is a direct plug-in replacement for 4044
- Am9244 pin and function compatible with Am9044 and 4044 plus  $\overline{CS}$  power down feature
- Fully static – no clocking
- Identical access and cycle time
- High output drive –  
 4.0mA sink current @ 0.4V
- TTL identical interface logic levels
- 100% MIL-STD-883 reliability assurance testing

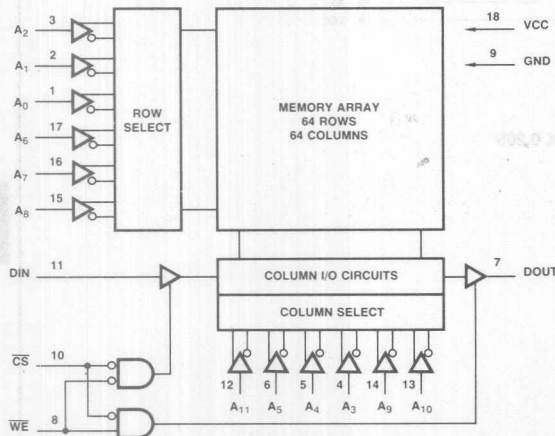
### GENERAL DESCRIPTION

The Am9044 and Am9244 are high performance, static, N-Channel, read/write, random access memories organized as 4096 x 1. Operation is from a single 5V supply, and all input/output levels are identical to standard TTL specifications. Low power versions of both devices are available with power savings of about 30%. The Am9044 and Am9244 are the same except that the Am9244 offers an automatic  $\overline{CS}$  power down feature.

The Am9244 remains in a low power standby mode as long as  $\overline{CS}$  remains high, thus reducing its power requirements. The Am9244 power decreases from 385mW to 165mW in the standby mode, and the Am92L44 from 275mW to 110mW. The  $\overline{CS}$  input does not affect the power dissipation of the Am9044.

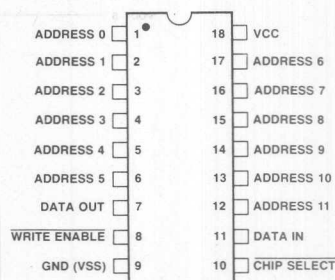
Data readout is not destructive and the same polarity as data input.  $\overline{CS}$  provides for easy selection of an individual package when the outputs are OR-tied. The outputs of 4.0mA for Am9244 and Am9044 provide increased short circuit current for improved capacitive drive.

### BLOCK DIAGRAM



MOS-256

### CONNECTION DIAGRAM



Top View

Pin 1 is marked for orientation.

MOS-257

### ORDERING INFORMATION

| Ambient Temperature             | Package Type | ICC Current Level | Access Times |            |            |           |            |            |            |           |
|---------------------------------|--------------|-------------------|--------------|------------|------------|-----------|------------|------------|------------|-----------|
|                                 |              |                   | Am9044       |            |            |           | Am9244     |            |            |           |
|                                 |              |                   | 450ns        | 300ns      | 250ns      | 200ns     | 450ns      | 300ns      | 250ns      | 200ns     |
| 0°C ≤ T <sub>A</sub> ≤ +70°C    | Plastic      | 70mA              | AM9044BPC    | AM9044CPC  | AM9044DPC  | AM9044EPC | AM9244BPC  | AM9244CPC  | AM9244DPC  | AM9244EPC |
|                                 |              | 50mA              | AM90L44BPC   | AM90L44CPC | AM90L44DPC |           | AM92L44BPC | AM92L44CPC | AM92L44DPC |           |
|                                 | Hermetic     | 70mA              | AM9044BDC    | AM9044CDC  | AM9044DDC  | AM9044EDC | AM9244BDC  | AM9244CDC  | AM9244DDC  | AM9244EDC |
|                                 |              | 50mA              | AM90L44BDC   | AM90L44CDC | AM90L44DDC |           | AM92L44BDC | AM92L44CDC | AM92L44DDC |           |
| -55°C ≤ T <sub>A</sub> ≤ +125°C | Hermetic     | 90mA              | AM9044BDM    | AM9044CDM  | AM9044DDM  |           | AM9244BDM  | AM9244CDM  | AM9244DDM  |           |
|                                 |              | 60mA              | AM90L44BDM   | AM90L44CDM |            |           | AM92L44BDM | AM92L44CDM |            |           |

**MAXIMUM RATINGS** beyond which useful life may be impaired

|   |                 |
|---|-----------------|
| Storage Temperature                     | -65°C to +150°C |
| Ambient Temperature Under Bias          | -55°C to +125°C |
| VCC with Respect to VSS                 | -0.5V to +7.0V  |
| All Signal Voltages with Respect to VSS | -0.5V to +7.0V  |
| Power Dissipation (Package Limitation)  | 1.0W            |
| DC Output Current                       | 10mA            |

The products described by this specification include internal circuitry designed to protect input devices from damaging accumulations of static charge. It is suggested nevertheless, that conventional precautions be observed during storage, handling and use in order to avoid exposure to excessive voltages.

**OPERATING RANGE**

| Part Number  | Ambient Temperature                                   | VSS | VCC              | Part Number                                    | Ambient Temperature                                      | VSS | VCC              |
|--|---|-----|------------------|--|--|-----|------------------|
| Am9044DC/PC<br>Am90L44DC/PC<br>Am9244DC/PC<br>Am92L44DC/PC | $0^{\circ}\text{C} \leq T_A \leq +70^{\circ}\text{C}$ | 0V  | +5.0V $\pm 10\%$ | Am9044DM<br>Am90L44DM<br>Am9244DM<br>Am92L44DM | $-55^{\circ}\text{C} \leq T_A \leq +125^{\circ}\text{C}$ | 0V  | +5.0V $\pm 10\%$ |

**ELECTRICAL CHARACTERISTICS** over operating range

| Parameter | Description                | Test Conditions  | Am9244XX<br>Am92L44XX |      |      | Am9044XX<br>Am90L44XX |      |      | Units |
|-----------|----------------------------|--|-----------------------|------|------|-----------------------|------|------|-------|
|           |                            |  | Min.                  | Typ. | Max. | Min.                  | Typ. | Max. |       |
| IOH       | Output High Current        | VOH = 2.4V<br>VCC = 4.5V<br>70°C                                       | -1.0                  |      |      | -1.0                  |      |      | mA    |
|           |                            | VOH = 2.4V<br>VCC = 4.5V<br>125°C                                      | -4                    |      |      | -4                    |      |      |       |
| IOL       | Output Low Current         | VOL = 0.4V<br>T <sub>A</sub> = +70°C                                   | 4.0                   |      |      | 4.0                   |      |      | mA    |
|           |                            | T <sub>A</sub> = +125°C  | 3.2                   |      |      | 3.2                   |      |      |       |
| VIH       | Input High Voltage         |  | 2.0                   |      | VCC  | 2.0                   |      | VCC  | Volts |
| VIL       | Input Low Voltage          |  | -0.5                  |      | 0.8  | -0.5                  |      | 0.8  | Volts |
| IIX       | Input Load Current         | VSS $\leq V_I \leq VCC$  |                       |      | 10   |                       |      | 10   | μA    |
| IOZ       | Output Leakage Current     | 0.4V $\leq V_O \leq VCC$<br>Output Disabled<br>T <sub>A</sub> = +125°C | -50                   |      | 50   | -50                   |      | 50   | μA    |
|           |                            | T <sub>A</sub> = +70°C   | -10                   |      | 10   | -10                   |      | 10   |       |
| CI        | Input Capacitance (Note 1) | Test Frequency = 1.0MHz  |                       | 3.0  | 5.0  |                       | 3.0  | 5.0  | pF    |
| CI/O      | I/O Capacitance (Note 1)   | T <sub>A</sub> = 25°C, All pins at 0V                                  |                       | 5.0  | 6.0  |                       | 5.0  | 6.0  |       |

6

**ELECTRICAL CHARACTERISTICS** over operating range

| Parameter | Description                                  | Test Conditions                                       | Am92L44 |      | Am9244 |      | Am90L44 |      | Am9044 |      | Units |
|-----------|--|---|---------|------|--------|------|---------|------|--------|------|-------|
|           |  |   | Typ.    | Max. | Typ.   | Max. | Typ.    | Max. | Typ.   | Max. |       |
| ICC       | VCC Operating Supply Current                 | Max. VCC $\overline{CS} \leq VIL$<br>for Am9244/92L44 |         | 50   |        | 70   |         | 50   |        | 70   | mA    |
|           |  | T <sub>A</sub> = 0°C<br>T <sub>A</sub> = -55°C        |         | 60   |        | 80   |         | 60   |        | 80   |       |
| IPD       | Automatic $\overline{CS}$ Power Down Current | Max. VCC<br>( $\overline{CS} \geq V_{IH}$ )           |         | 20   |        | 30   |         | -    |        | -    | mA    |
|           |  | T <sub>A</sub> = 0°C<br>T <sub>A</sub> = -55°C        |         | 22   |        | 33   |         | -    |        | -    |       |

## Notes:

- Typical values are for T<sub>A</sub> = 25°C, nominal supply voltage and nominal processing parameters.
- For test purposes, not more than one output at a time should be shorted. Short circuit test duration should not exceed 30 seconds.
- Test conditions assume signal transition times of 10ns or less, timing reference levels of 1.5V and output loading of one standard TTL gate plus 100pF.

- The internal write time of the memory is defined by the overlap of  $\overline{CS}$  low and  $\overline{WE}$  low. Both signals must be low to initiate a write and either signal can terminate a write by going high. The data input setup and hold timing should be referenced to the rising edge of the signal that terminates the write.
- Chip Select access time (t<sub>CO</sub>) is longer for the Am9244 than for the Am9044. The specified address access time will be valid only when Chip Select is low soon enough for t<sub>CO</sub> to elapse.



# Am9044 • Am9244

## SWITCHING CHARACTERISTICS over operating range (Note 3)

| Parameter | Description | Am9044B<br>Am9244B |      | Am9044C<br>Am9244C |      | Am9044D<br>Am9244D |      | Am9044E<br>Am9244E |      | Units |
|-----------|-------------|--------------------|------|--------------------|------|--------------------|------|--------------------|------|-------|
|           |             | Min.               | Max. | Min.               | Max. | Min.               | Max. | Min.               | Max. |       |

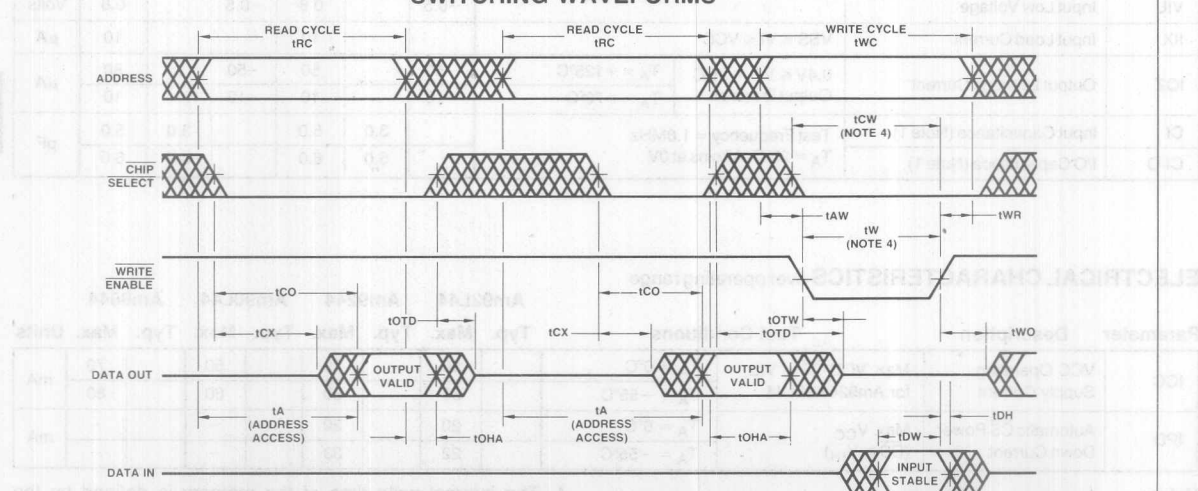
### Read Cycle

|                  |   |        |     |     |     |     |     |     |     |     |
|------------------|---|--------|-----|-----|-----|-----|-----|-----|-----|-----|
| t <sub>RC</sub>  | Address Valid to Address Do Not Care Time (Read Cycle Time) | 450    |     | 300 |     | 250 |     | 200 |     |     |
| t <sub>A</sub>   | Address Valid to Data Out Valid Delay (Address Access Time) |        | 450 |     | 300 |     | 250 |     | 200 |     |
| t <sub>CO</sub>  | Chip Select Low to Data Out Valid (Note 5)                  | Am9044 | 100 |     | 100 |     | 70  |     | 70  | ns  |
|                  |   | Am9244 |     | 450 |     | 300 |     | 250 |     | 200 |
| t <sub>CX</sub>  | Chip Select Low to Data Out On                              | 20     |     | 20  |     | 20  |     | 20  |     |     |
| t <sub>OTD</sub> | Chip Select High to Data Out Off                            |        | 100 |     | 80  |     | 60  |     | 60  |     |
| t <sub>OHA</sub> | Address Unknown to Data Out Unknown Time                    | 20     |     | 20  |     | 20  |     | 20  |     |     |

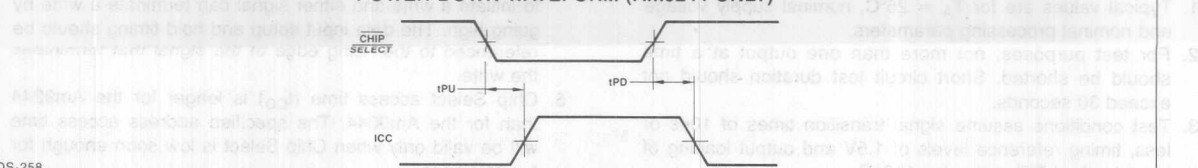
### Write Cycle

|                  |  |        |     |     |     |     |     |     |     |    |
|------------------|--|--------|-----|-----|-----|-----|-----|-----|-----|----|
| t <sub>WC</sub>  | Address Valid to Address Do Not Care Time (Write Cycle Time) | 450    |     | 300 |     | 250 |     | 200 |     |    |
| t <sub>W</sub>   | Write Enable Low to Write Enable High Time (Note 4)          | Am9044 | 200 |     | 150 |     | 100 |     | 100 | ns |
|                  |  | Am9244 | 250 |     | 200 |     | 150 |     | 150 |    |
| t <sub>WR</sub>  | Write Enable High to Address Do Not Care Time                | 0      |     | 0   |     | 0   |     | 0   |     |    |
| t <sub>OTW</sub> | Write Enable Low to Data Out Off Delay                       |        | 100 |     | 80  |     | 60  |     | 60  |    |
| t <sub>DW</sub>  | Data In Valid to Write Enable High Time                      | 200    |     | 150 |     | 100 |     | 100 |     |    |
| t <sub>DH</sub>  | Write Enable Low to Data In Do Not Care Time                 | 0      |     | 0   |     | 0   |     | 0   |     |    |
| t <sub>AW</sub>  | Address Valid to Write Enable Low Time                       | 0      |     | 0   |     | 0   |     | 0   |     |    |
| t <sub>PD</sub>  | Chip Select High to Power Low Delay (Am9244 only)            |        | 200 |     | 150 |     | 100 |     | 100 |    |
| t <sub>PU</sub>  | Chip Select Low to Power High Delay (Am9244 only)            | 0      |     | 0   |     | 0   |     | 0   |     |    |
| t <sub>CW</sub>  | Chip Select Low to Write Enable High Time (Note 4)           | Am9044 | 200 |     | 150 |     | 100 |     | 100 | ns |
|                  |  | Am9244 | 250 |     | 200 |     | 150 |     | 150 |    |
| t <sub>WO</sub>  | Write Enable High To Output Turn On                          |        | 100 |     | 100 |     | 70  |     | 70  |    |

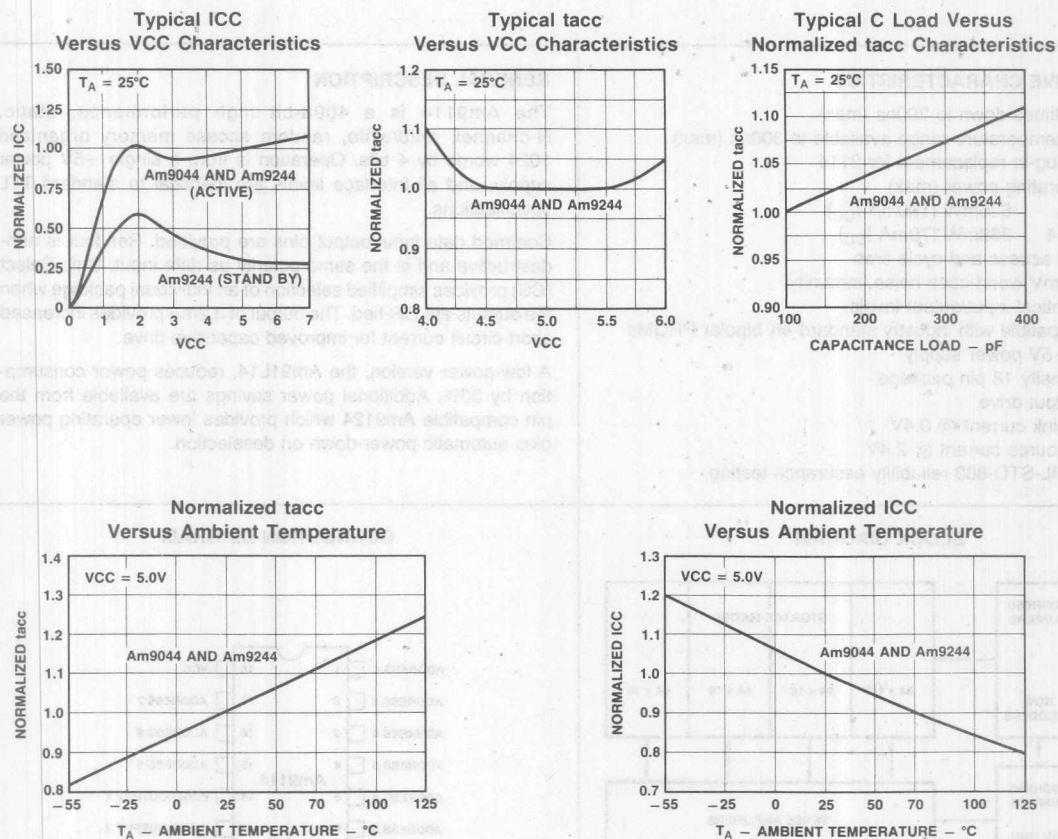
## SWITCHING WAVEFORMS



## POWER DOWN WAVEFORM (Am9244 ONLY)



## TYPICAL CHARACTERISTICS



MOS-259

## BIT MAP

| Address Designators |          |
|---------------------|----------|
| External            | Internal |
| A0                  | A2       |
| A1                  | A1       |
| A2                  | A0       |
| A3                  | A8       |
| A4                  | A9       |
| A5                  | A10      |
| A6                  | A3       |
| A7                  | A4       |
| A8                  | A5       |
| A9                  | A7       |
| A10                 | A6       |
| A11                 | A11      |

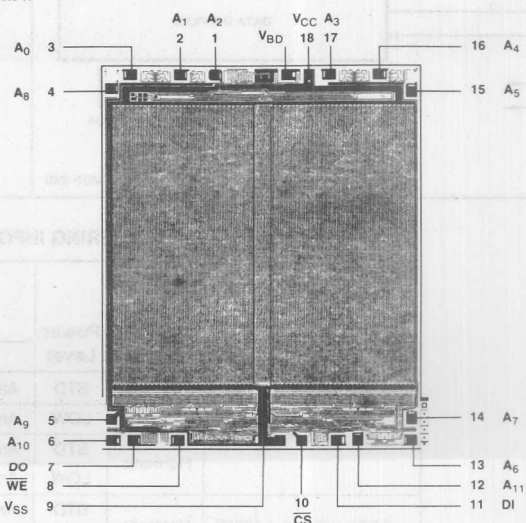


Figure 1. Bit Mapping Information.

# Am9114

## 1024 x 4 Static R/W Random Access Memory

### DISTINCTIVE CHARACTERISTICS

- Access times down to 200ns (max)
- Military temperature range available to 300ns (max)
- Direct plug-in replacement for 2114
- Low operating power (max)
  - Am9114 525mW (100mA  $I_{CC}$ )
  - Am91L14 368mW (70mA  $I_{CC}$ )
- Identical access and cycle time
- Full 400mV worst-case noise immunity
- TTL identical input/output levels
- Pin compatible with industry standard 4K bipolar PROMs
- Single +5V power supply
- High density 18 pin package
- High output drive
  - 3.2mA sink current @ 0.4V
  - 1.0mA source current @ 2.4V
- 100% MIL-STD-883 reliability assurance testing

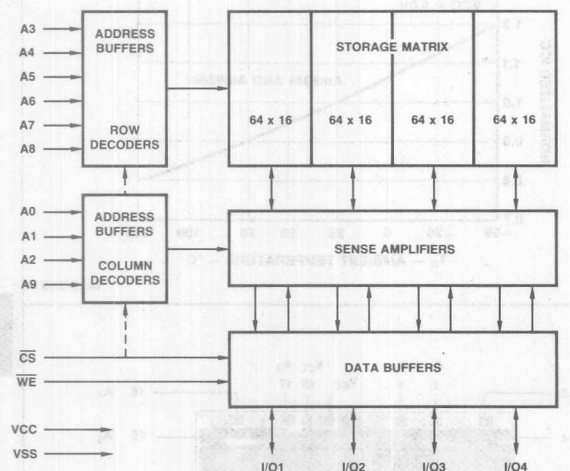
### GENERAL DESCRIPTION

The Am9114 is a 4096-bit high performance, static, N-channel, read/write, random access memory organized 1024 words by 4 bits. Operation is from a single +5V power supply, and all interface levels are identical to standard TTL specifications.

Common data input/output pins are provided. Readout is non-destructive and is the same polarity as data input. Chip Select (CS) provides simplified selection of an individual package when the outputs are OR-tied. The output of 3.2mA provides increased short-circuit current for improved capacitive drive.

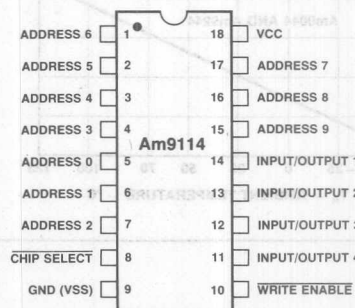
A low-power version, the Am91L14, reduces power consumption by 30%. Additional power savings are available from the pin compatible Am9124 which provides lower operating power plus automatic power-down on deselection.

### BLOCK DIAGRAM



MOS-260

### CONNECTION DIAGRAM



Top View  
Pin 1 is marked for orientation.

MOS-261

### ORDERING INFORMATION

| Ambient Temperature             | Package Type | Power Level | Access Times |            |           |
|---------------------------------|--------------|-------------|--------------|------------|-----------|
|                                 |              |             | 450ns        | 300ns      | 200ns     |
| 0°C ≤ T <sub>A</sub> ≤ 70°C     | Molded       | STD         | Am9114BPC    | Am9114CPC  | Am9114EPC |
|                                 |              | LOW         | Am91L14BPC   | Am91L14CPC |           |
|                                 | Hermetic     | STD         | Am9114BDC    | Am9114CDC  | Am9114EDC |
|                                 |              | LOW         | Am91L14BDC   | Am91L14CDC |           |
| -55°C ≤ T <sub>A</sub> ≤ +125°C | Hermetic     | STD         | Am9114BDM    | Am9114CDM  |           |
|                                 |              | LOW         | Am91L14BDM   | Am91L14CDM |           |

**MAXIMUM RATINGS** beyond which useful life may be impaired

|   |                 |
|---|-----------------|
| Storage Temperature                                 | -65°C to +150°C |
| Ambient Temperature Under Bias                      | -55°C to +125°C |
| V <sub>CC</sub> with Respect to V <sub>SS</sub>     | -0.5V to +7.0V  |
| All Signal Voltages with Respect to V <sub>SS</sub> | -0.5V to +7.0V  |
| Power Dissipation (Package Limitation)              | 1.0W            |
| DC Output Current                                   | 10mA            |

The products described by this specification include internal circuitry designed to protect input devices from damaging accumulations of static charge. It is suggested nevertheless, that conventional precautions be observed during storage, handling and use in order to avoid exposure to excessive voltages.

**OPERATING RANGE**

| Part Number                 | Ambient Temperature             | V <sub>SS</sub> | V <sub>CC</sub> |
|-----------------------------|---------------------------------|-----------------|-----------------|
| Am9114DC/PC<br>Am91L14DC/PC | 0°C ≤ T <sub>A</sub> ≤ +70°C    | 0V              | +5.0V ±5%       |
| Am9114DM<br>Am91L14DM       | -55°C ≤ T <sub>A</sub> ≤ +125°C | 0V              | +5.0V ±10%      |

**ELECTRICAL CHARACTERISTICS** over operating range

| Parameter        | Description                       | Test Conditions   | Am9114 |      |                 | Am91L14 |      |                 | Units |
|------------------|-----------------------------------|---|--------|------|-----------------|---------|------|-----------------|-------|
|                  |                                   |   | Min.   | Typ. | Max.            | Min.    | Typ. | Max.            |       |
| V <sub>OH</sub>  | Output High Voltage               | T <sub>A</sub> = 70°C, I <sub>OH</sub> = -1.0mA                       | 2.4    |      |                 | 2.4     |      |                 | Volts |
|                  |                                   | T <sub>A</sub> = 125°C, I <sub>OH</sub> = -1.0mA                      | 2.2    |      |                 | 2.2     |      |                 |       |
| V <sub>OL</sub>  | Output Low Voltage                | T <sub>A</sub> = 125°C, I <sub>OL</sub> = 2.4mA                       |        |      | 0.4             |         |      | 0.4             | Volts |
|                  |                                   | T <sub>A</sub> = 70°C, I <sub>OL</sub> = 3.2mA                        |        |      | 0.4             |         |      | 0.4             |       |
| V <sub>IH</sub>  | Input High Voltage                |   | 2.0    |      | V <sub>CC</sub> | 2.0     |      | V <sub>CC</sub> | Volts |
| V <sub>IL</sub>  | Input Low Voltage                 |   | -0.5   |      | 0.8             | -0.5    |      | 0.8             | Volts |
| I <sub>Ix</sub>  | Input Load Current                | V <sub>SS</sub> ≤ V <sub>I</sub> ≤ V <sub>CC</sub>                    |        |      | 10              |         |      | 10              | μA    |
| I <sub>OZ</sub>  | Output Leakage Current            | V <sub>SS</sub> ≤ V <sub>O</sub> ≤ V <sub>CC</sub><br>Output Disabled |        |      |                 |         |      |                 | μA    |
|                  |                                   | T <sub>A</sub> = 125°C  | -50    |      | 50              | -50     |      | 50              |       |
|                  |                                   | T <sub>A</sub> = 70°C   | -10    |      | 10              | -10     |      | 10              |       |
| I <sub>OHS</sub> | Output High Short Circuit Current | (Note 2)  |        |      | 75              |         |      | 75              | mA    |
| I <sub>CC</sub>  | V <sub>CC</sub> Supply Current    | MAX. V <sub>CC</sub>  |        |      | 95              |         |      | 65              | mA    |
|                  |                                   | T <sub>A</sub> = 25°C   |        |      | 100             |         |      | 70              |       |
|                  |                                   | T <sub>A</sub> = -55°C  |        |      | 110             |         |      | 80              |       |
| C <sub>I</sub>   | Input Capacitance (Note 1)        | Test Frequency = 1.0MHz   |        | 3.0  | 5.0             |         | 3.0  | 5.0             | pF    |
| C <sub>IO</sub>  | I/O Capacitance (Note 1)          | T <sub>A</sub> = 25°C, All pins at 0V                                 |        | 5.0  | 6.0             |         | 5.0  | 6.0             |       |

**Notes:**

- Typical values are for T<sub>A</sub> = 25°C nominal supply voltage and nominal processing parameters.
- For test purposes, not more than one output at a time should be shorted. Short circuit test duration should not exceed 30 seconds.
- Test conditions assume signal transition times of 10ns or less, timing reference levels of 1.5V and output loading of one standard TTL gate plus 100pF.

- The internal write time of the memory is defined by the overlap of  $\overline{CS}$  low and  $\overline{WE}$  low. Both signals must be low to initiate a write and either signal can terminate a write by going high. The data input setup and hold timing should be referenced to the rising edge of the signal that terminates the write.



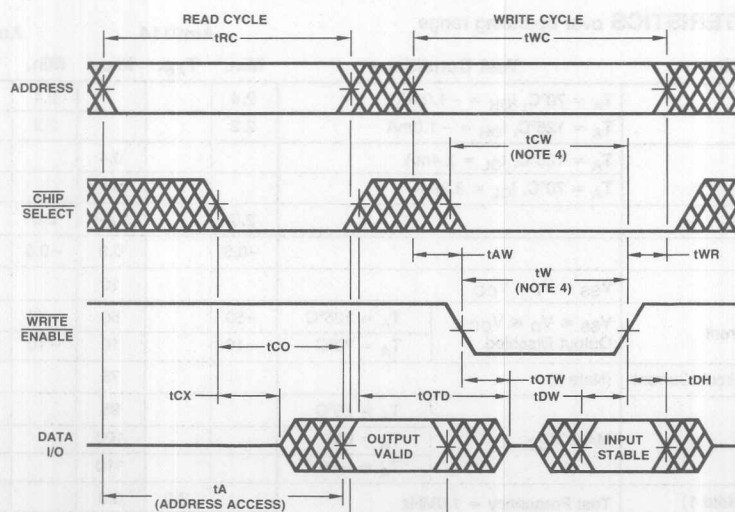
## SWITCHING CHARACTERISTICS over operating range (Note 3)

| SWITCHING CHARACTERISTICS over operating range (Note 3) |   | Am9114B |      | Am9114C |      | Am9114E |      |       |
|---|---|---------|------|---------|------|---------|------|-------|
| Parameter   | Description   | Min.    | Max. | Min.    | Max. | Min.    | Max. | Units |
| Read Cycle  |   |         |      |         |      |         |      |       |
| t <sub>RC</sub>   | Address Valid to Address Do Not Care Time (Red Cycle Time)  | 450     |      | 300     |      | 200     |      | ns    |
| t <sub>A</sub>  | Address Valid to Data Out Valid Delay (Address Access Time) |         | 450  |         | 300  |         | 200  |       |
| t <sub>CO</sub>   | Chip Select Low to Data Out Valid (Note 5)                  |         | 120  |         | 100  |         | 70   |       |
| t <sub>CX</sub>   | Chip Select Low to Data Out On                              | 20      |      | 20      |      | 20      |      |       |
| t <sub>OTD</sub>  | Chip Select High to Data Out Off                            |         | 100  |         | 80   |         | 60   |       |
| t <sub>OHA</sub>  | Address Unknown to Data Out Unknown Time                    | 50      |      | 50      |      | 50      |      |       |

**Write Cycle**

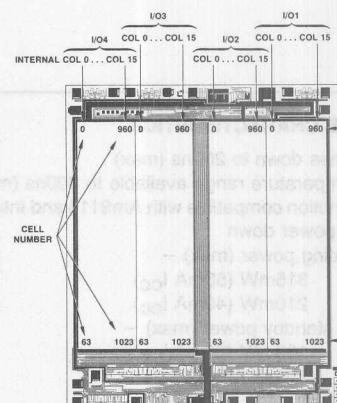
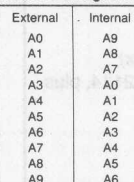
|           |  |     |     |     |    |     |    |    |
|-----------|--|-----|-----|-----|----|-----|----|----|
| $t_{WC}$  | Address Valid to Address Do Not Care Time (Write Cycle Time) | 450 |     | 300 |    | 200 |    | ns |
| $t_W$     | Write Enable Low to Write Enable High Time (Note 4)          | 200 |     | 150 |    | 120 |    |    |
| $t_{WR}$  | Write Enable High to Address Do Not Care Time                | 0   |     | 0   |    | 0   |    |    |
| $t_{OTW}$ | Write Enable Low to Data Out Off Delay                       |     | 100 |     | 80 |     | 60 |    |
| $t_{DW}$  | Data In Valid to Write Enable High Time                      | 200 |     | 150 |    | 120 |    |    |
| $t_{DH}$  | Write Enable Low to Data In Do Not Care Time                 | 0   |     | 0   |    | 0   |    |    |
| $t_{AW}$  | Address Valid to Write Enable Low Time                       | 0   |     | 0   |    | 0   |    |    |
| $t_{CW}$  | Chip Select Low to Write Enable High Time (Note 4)           | 200 |     | 150 |    | 120 |    |    |

## SWITCHING WAVEFORMS





## BIT MAP



DIE SIZE 0.137" X 0.168"

# Am9124

1024 x 4 Static R/W Random Access Memory

## DISTINCTIVE CHARACTERISTICS

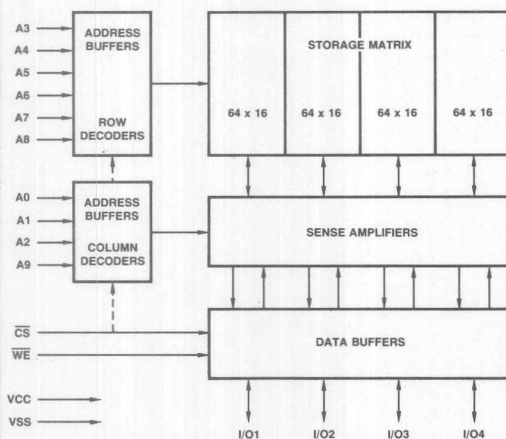
- Access times down to 200ns (max)
- Military temperature range available to 300ns (max)
- Pin and function compatible with Am9114 and Intel 2114, plus automatic power down
- Low operating power (max) –
  - Am9124 315mW (60mA  $I_{CC}$ )
  - Am91L24 210mW (40mA  $I_{CC}$ )
- Automatic standby power (max) –
  - Am9124 105mW (20mA  $I_{CC}$ )
  - Am91L24 79mW (15mA  $I_{CC}$ )
- Identical access and cycle time
- TTL identical input/output levels
- Full 400mV worst-case noise immunity
- Pin compatible with industry standard 4K bipolar PROMs
- Single +5V power supply
- High density 18 pin package
- High output drive –
  - 4.0mA sink current @ 0.4V
  - 1.0mA source current @ 2.4V
- 100% MIL-STD-883 reliability assurance testing

## GENERAL DESCRIPTION

The Am9124 is a 4096-bit, low-power, high performance, static, N-channel, read/write, random access memory organized 1024 words by 4 bits. Operation is from a single +5V power supply, and all interface levels are identical to standard TTL specifications. The device is pin and functional compatible with the Am9114 with the added benefits of 40% less operating power plus automatic Chip Select power-down that reduces power an additional 60%. The supply current advantage of the Am9124 vs. the 2114/Am9114 are shown in Figure 1.

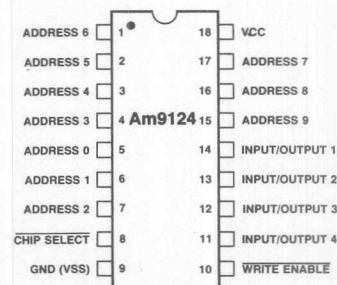
Common data input/output pins are provided. Readout is non-destructive and is the same polarity as data input. Chip Select ( $\overline{CS}$ ) automatically controls power-down and provides simplified selection of an individual package when the outputs are OR-tied. The output of 4.0mA provides increased short-circuit current for improved capacitive drive.

## BLOCK DIAGRAM



MOS-263

## CONNECTION DIAGRAM



Top View  
Pin 1 is marked for orientation.

MOS-264

## ORDERING INFORMATION

| Ambient Temperature                                      | Package Type | Power Level | Access Times |            |           |
|--|--------------|-------------|--------------|------------|-----------|
|  |              |             | Am9124       |            |           |
|  |              |             | 450ns        | 300ns      | 200ns     |
| $0^{\circ}\text{C} \leq T_A \leq 70^{\circ}\text{C}$     | Molded       | STD         | Am9124BPC    | Am9124CPC  | Am9124EPC |
|  |              | LOW         | Am91L24BPC   | Am91L24CPC |           |
|  | Hermetic     | STD         | Am9124BDC    | Am9124CDC  | Am9124EDC |
|  |              | LOW         | Am91L24BDC   | Am91L24CDC |           |
| $-55^{\circ}\text{C} \leq T_A \leq +125^{\circ}\text{C}$ | Hermetic     | STD         | Am9124BDM    | Am9124CDM  |           |
|  |              | LOW         | Am91L24BDM   | Am91L24CDM |           |

**MAXIMUM RATINGS** beyond which useful life may be impaired

|  |                 |
|--|-----------------|
| Storage Temperature                          | -65°C to +150°C |
| Ambient Temperature Under Bias               | -55°C to +125°C |
| $V_{CC}$ with Respect to $V_{SS}$            | -0.5V to +7.0V  |
| All Signal Voltages with Respect to $V_{SS}$ | -0.5V to +7.0V  |
| Power Dissipation (Package Limitation)       | 1.0W            |
| DC Output Current                            | 10mA            |

The products described by this specification include internal circuitry designed to protect input devices from damaging accumulations of static charge. It is suggested nevertheless, that conventional precautions be observed during storage, handling and use in order to avoid exposure to excessive voltages.

**OPERATING RANGE**

| Part Number                 | Ambient Temperature    | $V_{SS}$ | $V_{CC}$   |
|-----------------------------|------------------------|----------|------------|
| Am9124DC/PC<br>Am91L24DC/PC | 0°C ≤ $T_A$ ≤ +70°C    | 0V       | +5.0V ±5%  |
| Am9124DM<br>Am91L24DM       | -55°C ≤ $T_A$ ≤ +125°C | 0V       | +5.0V ±10% |

**ELECTRICAL CHARACTERISTICS** over operating range

| Parameter | Description                        | Test Conditions   | Am9124                    |      |          | Am91L24 |      |          | Units |
|-----------|------------------------------------|---|---------------------------|------|----------|---------|------|----------|-------|
|           |                                    |   | Min.                      | Typ. | Max.     | Min.    | Typ. | Max.     |       |
| $V_{OH}$  | Output High Voltage                | $T_A = 70^\circ\text{C}$ , $I_{OH} = -1.4\text{mA}$           | 2.4                       |      |          | 2.4     |      |          | Volts |
|           |                                    | $T_A = 125^\circ\text{C}$ , $I_{OH} = -1.0\text{mA}$          | 2.2                       |      |          | 2.2     |      |          |       |
| $V_{OL}$  | Output Low Voltage                 | $T_A = 125^\circ\text{C}$ , $I_{OL} = 3.2\text{mA}$           |                           |      | 0.4      |         |      | 0.4      | Volts |
|           |                                    | $T_A = 70^\circ\text{C}$ , $I_{OL} = 4.0\text{mA}$            |                           |      | 0.4      |         |      | 0.4      |       |
| $V_{IH}$  | Input High Voltage                 |   | 2.0                       |      | $V_{CC}$ | 2.0     |      | $V_{CC}$ | Volts |
| $V_{IL}$  | Input Low Voltage                  |   | -0.5                      |      | 0.8      | -0.5    |      | 0.8      | Volts |
| $I_{IX}$  | Input Load Current                 | $V_{SS} \leq V_I \leq V_{CC}$                                 |                           |      | 10       |         |      | 10       | μA    |
| $I_{OZ}$  | Output Leakage Current             | $V_{SS} \leq V_O \leq V_{CC}$<br>Output Disabled              | $T_A = 125^\circ\text{C}$ | -50  | 50       | -50     |      | 50       | μA    |
|           |                                    |   | $T_A = 70^\circ\text{C}$  | -10  | 10       | -10     |      | 10       |       |
| $I_{OHS}$ | Output High Short Circuit Current  | (Note 2)  | $T_A = 0^\circ\text{C}$   |      | 95       |         |      | 95       | mA    |
|           |                                    |   | $T_A = -55^\circ\text{C}$ |      | 115      |         |      | 115      |       |
| $I_{CC}$  | $V_{CC}$ Operating Supply Current  | MAX. $V_{CC}$ ( $\overline{CS} \leq V_{IL}$ )                 | $T_A = 25^\circ\text{C}$  |      | 55       |         |      | 37       | mA    |
|           |                                    |   | $T_A = 0^\circ\text{C}$   |      | 60       |         |      | 40       |       |
|           |                                    |   | $T_A = -55^\circ\text{C}$ |      | 70       |         |      | 50       |       |
| $I_{PD}$  | $V_{CC}$ Power Down Supply Current | MAX. $V_{CC}$ ( $\overline{CS} \leq V_{IH}$ )<br>(Deselected) | $T_A = 25^\circ\text{C}$  |      | 19       |         |      | 14       | mA    |
|           |                                    |   | $T_A = 0^\circ\text{C}$   |      | 20       |         |      | 15       |       |
|           |                                    |   | $T_A = -55^\circ\text{C}$ |      | 22       |         |      | 17       |       |
| $C_I$     | Input Capacitance (Note 1)         | Test Frequency = 1.0MHz                                       |                           | 3.0  | 5.0      |         | 3.0  | 5.0      | pF    |
| $C_{IO}$  | I/O Capacitance (Note 1)           | $T_A = 25^\circ\text{C}$ , All pins at 0V                     |                           | 5.0  | 6.0      |         | 5.0  | 6.0      |       |

## Notes:

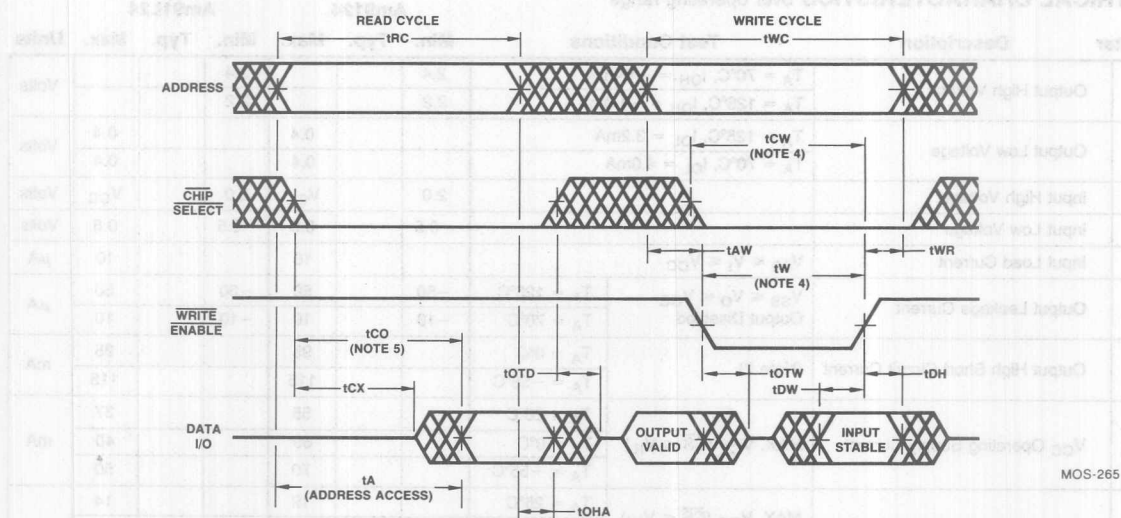
- Typical values are for  $T_A = 25^\circ\text{C}$  nominal supply voltage and nominal processing parameters.
- For test purposes, not more than one output at a time should be shorted. Short circuit test duration should not exceed 30 seconds.
- Test conditions assume signal transition times of 10ns or less, timing reference levels of 1.5V and output loading of one standard TTL gate plus 100pF.
- The internal write time of the memory is defined by the overlap of  $\overline{CS}$  low and  $\overline{WE}$  low. Both signals must be low to initiate a write and either signal can terminate a write by going high. The data input setup and hold timing should be referenced to the rising edge of the signal that terminates the write.
- Chip Select access time ( $t_{CO}$ ) is longer for the Am9124 than for the Am9114/2114. The specified address access time will be valid only when Chip Select is low soon enough for  $t_{CO}$  to elapse.

|           |   |     |     |     |     |     |     |    |
|-----------|---|-----|-----|-----|-----|-----|-----|----|
| $t_{RC}$  | Address Valid to Address Do Not Care Time (Red Cycle Time)  | 450 |     | 300 |     | 200 |     |    |
| $t_A$     | Address Valid to Data Out Valid Delay (Address Access Time) |     | 450 |     | 300 |     | 200 |    |
| $t_{CO}$  | Chip Select Low to Data Out Valid (Note 5)                  |     | 420 |     | 280 |     | 185 |    |
| $t_{CX}$  | Chip Select Low to Data Out On                              | 20  |     | 20  |     | 20  |     | ns |
| $t_{OTD}$ | Chip Select High to Data Out Off                            |     | 100 |     | 80  |     | 60  |    |
| $t_{OHA}$ | Address Unknown to Data Out Unknown Time                    | 50  |     | 50  |     | 50  |     |    |

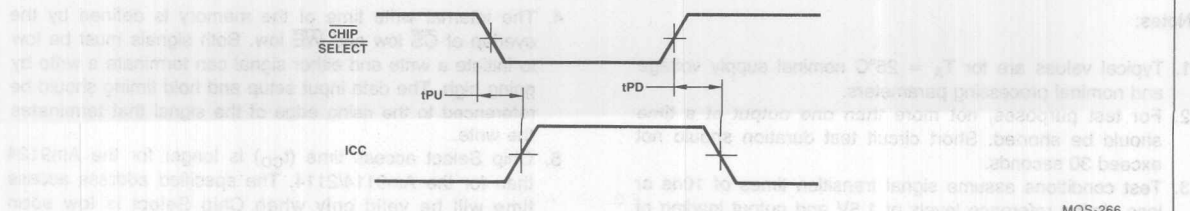
#### Write Cycle

|           |  |     |     |     |     |     |     |    |
|-----------|--|-----|-----|-----|-----|-----|-----|----|
| $t_{WC}$  | Address Valid to Address Do Not Care Time (Write Cycle Time) | 450 |     | 300 |     | 200 |     |    |
| $t_W$     | Write Enable Low to Write Enable High Time (Note 4)          | 250 |     | 200 |     | 150 |     |    |
| $t_{WR}$  | Write Enable High to Address Do Not Care Time                | 0   |     | 0   |     | 0   |     |    |
| $t_{OTW}$ | Write Enable Low to Data Out Off Delay                       |     | 100 |     | 80  |     | 60  |    |
| $t_{DW}$  | Data In Valid to Write Enable High Time                      | 200 |     | 150 |     | 120 |     | ns |
| $t_{DH}$  | Write Enable Low to Data In Do Not Care Time                 | 0   |     | 0   |     | 0   |     |    |
| $t_{AW}$  | Address Valid to Write Enable Low Time                       | 0   |     | 0   |     | 0   |     |    |
| $t_{PD}$  | Chip Select High to Power Low Delay                          |     | 200 |     | 150 |     | 100 |    |
| $t_{PU}$  | Chip Select Low to Power High Delay                          | 0   |     | 0   |     | 0   |     |    |
| $t_{CW}$  | Chip Select Low to Write Enable High Time (Note 4)           | 250 |     | 200 |     | 150 |     |    |

### SWITCHING WAVEFORMS



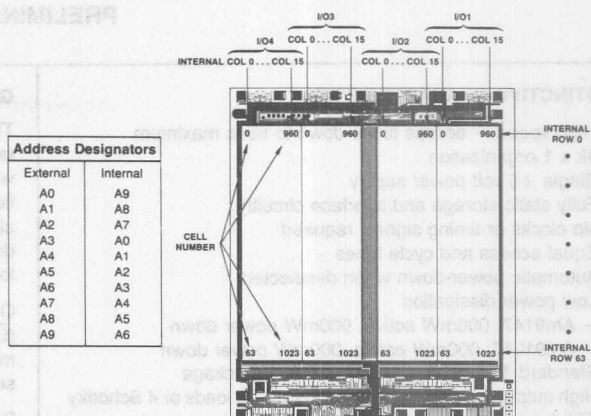
### POWER DOWN WAVEFORM



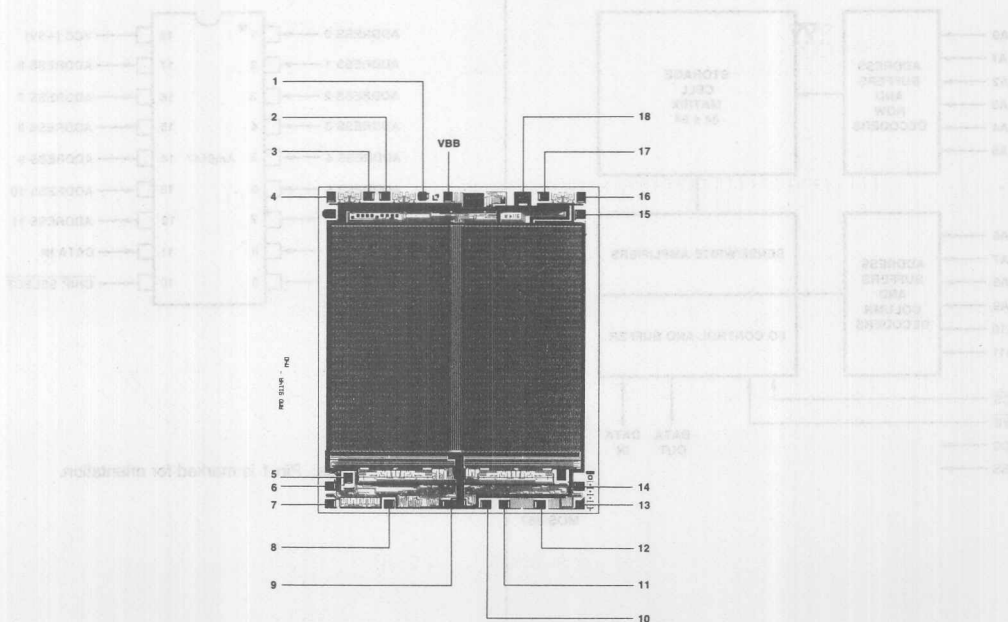
| Configuration | Part Number | Average Worst Case Current (mA at 0°C) |                |
|---------------|-------------|--|----------------|
|               |             | 100% Duty Cycle                        | 50% Duty Cycle |
| 2K x 8        | Am2114      | 400                                    | 400            |
|               | Am2114L     | 280                                    | 280            |
|               | Am9124      | 160                                    | 120            |
|               | Am91L24     | 110                                    | 85             |
| 4K x 12       | Am2114      | 1200                                   | 1200           |
|               | Am2114L     | 840                                    | 840            |
|               | Am9124      | 360                                    | 300            |
|               | Am92L24     | 255                                    | 217            |
| 8K x 16       | Am2114      | 3200                                   | 3200           |
|               | Am2114L     | 2240                                   | 2240           |
|               | Am9124      | 800                                    | 720            |
|               | Am91L24     | 580                                    | 530            |

Figure 1. Supply Current Advantages of Am9124 vs. Am2114.

## BIT MAP



## Metallization and Pad Layout



DIE SIZE 0.137" X 0.168"



# Am9147

4096 x 1 Static R/W Random Access Memory

PRELIMINARY

## DISTINCTIVE CHARACTERISTICS

- High speed – access times down to 55ns maximum
- 4k x 1 organization
- Single +5 volt power supply
- Fully static storage and interface circuitry
- No clocks or timing signals required
- Equal access and cycle times
- Automatic power-down when deselected
- Low power dissipation
  - Am9147: 000mW active, 000mW power down
  - Am91L47: 000mW active, 000mW power down
- Standard 18 pin, .300 inch dual in-line package
- High output drive – up to 00 standard TTL loads or 4 Schottky TTL loads
- TTL compatible interface levels
- 100% MIL-STD-883 reliability assurance testing

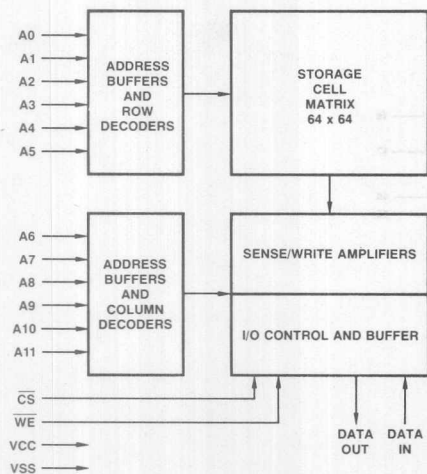
## GENERAL DESCRIPTION

The Am9147 is a high performance, 4096-bit, static, read/write, random access memory. It is organized as 4096 words by 1 bit per word. All interface signal levels are identical to TTL specifications, providing good noise immunity and simplified system design. All inputs are purely capacitive MOS loads. The outputs will drive up to 4 standard Schottky TTL loads or up to 5 standard TTL loads.

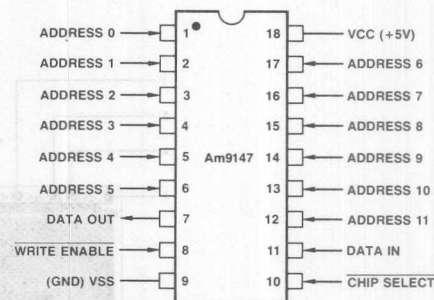
Only a single +5 volt power supply is required. When deselected ( $\overline{CS} \geq V_{IH}$ ), the Am9147 automatically enters a power-down mode which reduces power dissipation by more than 00%. When selected, the chip powers up again with no access time penalty.

Data In and Data Out use separate pins on the standard 18-pin package. Data Out is the same polarity as Data In. Data Out is a three-state signal allowing wired-or operation of several chips. Data In and Data Out may be connected together for operation in a common data bus environment.

## BLOCK DIAGRAM



## CONNECTION DIAGRAM Top View



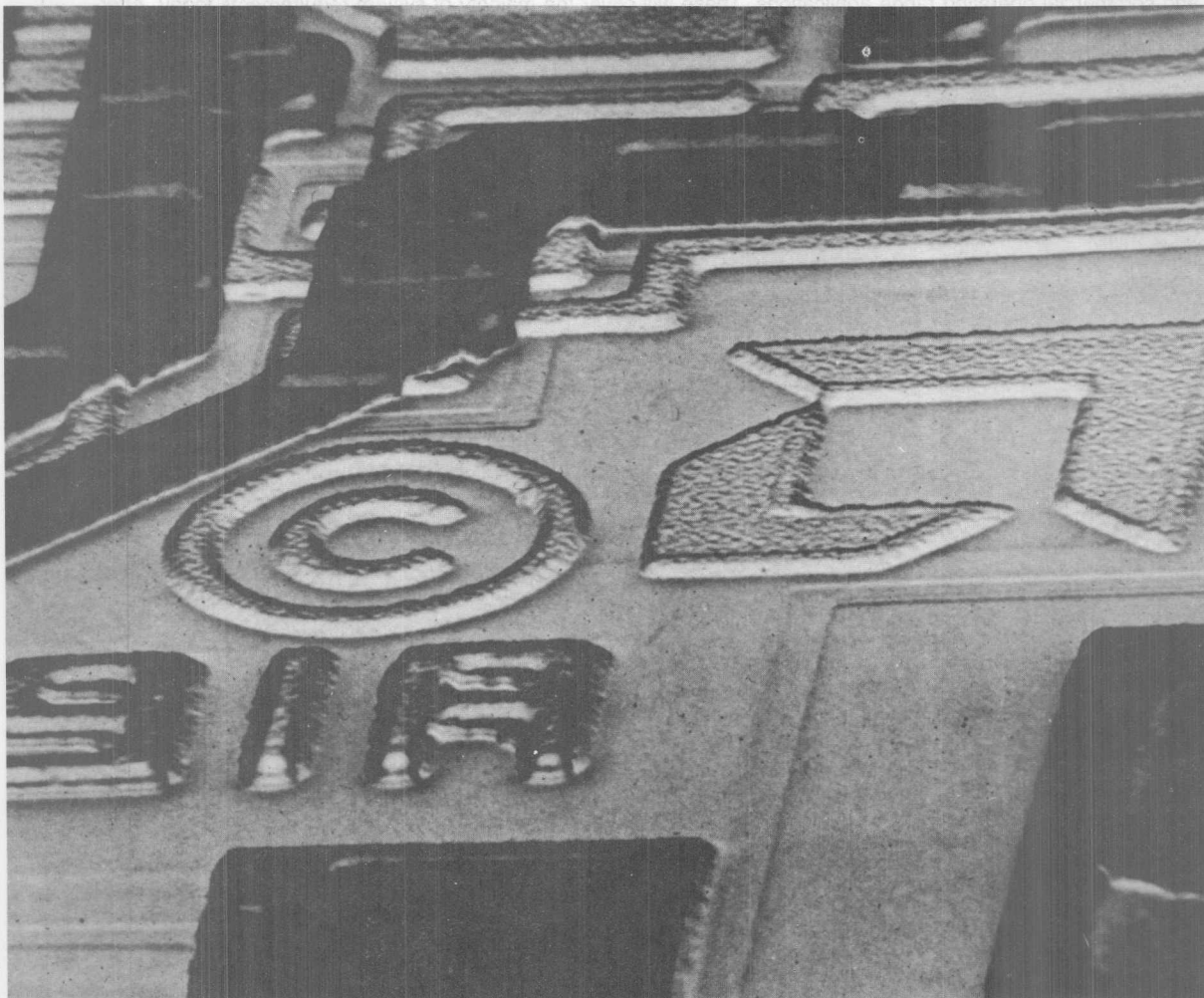
Note: Pin 1 is marked for orientation.

MOS-267

MOS-268

# Advanced Micro Devices Commitment to Excellence

## Product Assurance Programs for Military and Commercial Integrated Circuits



A

Advanced Micro Devices was conceived on the premise that there was a place in the semiconductor community for a manufacturer dedicated to excellence.

In product assurance procedures, Advanced Micro Devices is unique. Only Advanced Micro Devices processes all integrated circuits, commercial as well as military, to the demanding requirements of MIL-STD-883. The Rome Air Development Center (RADC), which is the Air Force's principal authority on component reliability, has issued MIL-HDBK-217B which indicates that parts processed to Military Standard 883, Level C (Advanced Micro Devices' standard processing) yield a product nearly ten times better in failure rates than the industry commercial average.

Our Sunnyvale facility has been certified by the Defense Electronics Supply Center (DESC) to produce parts to JAN Class B and C under Military Specification MIL-M-38510. The National Aeronautics and Space Administration (NASA) has certified this production line for the manufacture of Class A products for programs requiring the highest levels of reliability. Advanced Micro Devices is the only integrated circuit company formed within the last ten years to achieve such line certification.

This brochure outlines Advanced Micro Devices' standard programs for Class B, C and A devices for military and commercial operating range applications. These will cover the majority of system requirements today. Alternative screening flows for specific user needs can be performed on request. Check with your local sales office for further information.

# ADVANCED MICRO DEVICES' STANDARD PRODUCTS ARE MANUFACTURED TO MIL-STD-883 REQUIREMENTS

Advanced Micro Devices' product assurance programs are based on two key documents.

MIL-M-38510 – General Specification for Microcircuits

MIL-STD-883 – Test Methods and Procedures for Microelectronics

The screening charts in this brochure show that every integrated circuit shipped by Advanced Micro Devices receives the critical screening procedures defined in MIL-STD-883, Method 5004 for Class C product. This includes molded plastic devices.

In addition, documentation, design, processing and assembly workmanship guidelines are patterned after MIL-M-38510 specifications.

Commercial and industrial users receive the quality and reliability benefits of this aerospace-type screening and documentation at no additional cost.

## STANDARD PRODUCT TESTING CATEGORIES

Advanced Micro Devices offers integrated circuits to four standard testing categories.

1. Commercial operating range product (typically 0°C to 70°C)
2. Commercial product with 100% temperature testing
3. Military operating range product (typically -55°C to +125°C)
4. JAN qualified product

Categories 1, 2 and 3 are available on most Advanced Micro Devices circuits. Category 4 is offered on a more limited line. Check with your local sales office for details.

## STANDARD PRODUCT ASSURANCE CATEGORIES

Devices produced to the above testing categories are available to the three standard classes of product assurance defined by MIL-STD-883. As a minimum, every device shipped by Advanced Micro Devices meets the screening requirements of Class C.

**Class C – For commercial and ground-based military systems where replacement can be accomplished without difficulty.**

According to MIL-HDBK-217B, this assures relative failure rates 9.4 times better than that of regular industry commercial product.

**Class B – For flight applications and commercial systems where maintenance is difficult or expensive and where reliability is vital.**

Devices are upgraded from Class C to Class B by burn-in screening and additional testing.

According to MIL-HDBK-217B, Class B failure rate is improved 30 times over regular industry commercial product. Advanced Micro Devices Class B processing conforms to MIL-STD-883 requirements. MIL-HDBK-217B indicates that this may provide failure rates as much as two times better than some other manufacturers' "equivalent" or "pseudo" Class B programs.

**Class S – For space applications where replacement is extremely difficult or impossible and reliability is imperative.**

Class S screening includes x-ray and other special inspections tailored to the specific requirements of the user.

The 100% screening and quality conformance testing performed within these Advanced Micro Devices programs is shown in TABLES I, II and III. A full description of the process flow is provided in Product Assurance Document 15-010, available on request.

A



# CLASS C SCREENING FLOW FOR COMMERCIAL SYSTEMS AND GROUND BASED MILITARY SYSTEMS

**TABLE I  
CLASS C  
INTEGRATED CIRCUITS**

| Screening Procedure per MIL-STD-883<br>Method 5004, Class C |   | COMMERCIAL<br>OPERATING RANGE   |   | MILITARY<br>OPERATING RANGE |                             |
|---|---|---------------------------------|---|-----------------------------|-----------------------------|
|   |   | HERMETIC AND<br>MOLDED PACKAGES |   | HERMETIC<br>PACKAGE ONLY    |                             |
|   |   | C1                              | C2<br>Commercial<br>Product<br>With 100%<br>Temper-<br>ature<br>Testing | C3                          | C4                          |
| Screen  | Test Method                                       | Commercial<br>Product           | Commercial<br>Product<br>With 100%<br>Temper-<br>ature<br>Testing       | Military<br>Product         | Jan<br>Qualified<br>Product |
| VISUAL AND MECHANICAL                                       |   |                                 |   |                             |                             |
| Internal visual   | 2010, Condition B                                 | 100%                            | 100%  | 100%                        | 100%                        |
| High temperature<br>storage                                 | 1008, Condition C,<br>24 hours                    | 100%                            | 100%  | 100%                        | 100%                        |
| Temperature cycle   | 1010, Condition C                                 | 100%                            | 100%  | 100%                        | 100%                        |
| Constant<br>acceleration                                    | 2001  | 100% (1)                        | 100% (1)  | 100%                        | 100%                        |
| Hermeticity, Fine<br>and Gross                              | 1014  | 100% (1)                        | 100% (1)  | 100%                        | 100%                        |
| FINAL ELECTRICAL TESTS                                      |   | AMD Data<br>Sheet               | AMD Data<br>Sheet   | AMD Data<br>Sheet           | 38510 Slash<br>Sheet        |
| Static (dc)   | a) At 25°C, and power<br>supply extremes          | 100%                            | 100%  | 100%                        | 100%                        |
|   | b) At temperature<br>and power<br>supply extremes | (2)                             | 100% (3)  | —                           | —                           |
| Functional  | a) At 25°C, and power<br>supply extremes          | 100%                            | 100%  | 100%                        | 100%                        |
|   | b) At temperature<br>and power<br>supply extremes | (2)                             | 100% (3)  | —                           | —                           |
| Switching (ac)<br>or Dynamic                                | At 25°C, nominal<br>power supply                  | (2)                             | (2)   | —                           | —                           |
| QUALITY CONFORMANCE   | 5005, Group A<br>(See Table II)                   | Sample                          | Sample  | Sample                      | Sample                      |
| Sample Tests  | Group B   | —                               | —   | —                           | Sample                      |
|   | Group C   | —                               | —   | —                           | Sample                      |
|   | Group D   | —                               | —   | —                           | Sample                      |
| EXTERNAL VISUAL   | 2009 (Note 5)                                     | 100%                            | 100%  | 100%                        | 100%                        |

**TABLE II  
GROUP A QUALITY CONFORMANCE LEVELS**

Advanced Micro Devices employs the military-recommended LTPD sampling system to assure quality. MIL-STD-883, Method 5005, TABLE I, Group A, subgroups 1 through 9 as appropriate to the device family are performed on every lot. Quality levels defined for Class B product are applied by Advanced Micro Devices to both Class B and Class C orders.

|  | LTPD | INITIAL<br>SAMPLE SIZE |
|--|------|------------------------|
| Subgroup 1 – Static tests at 25°C  | 5    | 45                     |
| Subgroup 2 – Static tests at maximum rated operating temperature                           | 7    | 32                     |
| Subgroup 3 – Static tests at minimum rated operating temperature                           | 7    | 32                     |
| Subgroup 4 – Dynamic tests at 25°C – LINEAR devices  | 5    | 45                     |
| Subgroup 5 – Dynamic tests at maximum rated operating temperature<br>– LINEAR devices      | 7    | 32                     |
| Subgroup 6 – Dynamic tests at minimum rated operating temperature<br>– LINEAR devices      | 7    | 32                     |
| Subgroup 7 – Functional tests at 25°C  | 5    | 45                     |
| Subgroup 8 – Functional tests at maximum and minimum rated<br>operating temperatures       | 10   | 22                     |
| Subgroup 9 – Switching tests at 25°C – DIGITAL devices                                     | 7    | 32                     |
| Subgroup 10 – Switching tests at maximum rated operating<br>temperatures – DIGITAL devices | *    |                        |
| Subgroup 11 – Switching tests at minimum rated operating<br>temperatures – DIGITAL devices | * *  |                        |

\*These subgroups, where applicable, are usually performed during initial characterization only for all except JAN Qualified product.



## CLASS B SCREENING FLOW FOR HIGH RELIABILITY COMMERCIAL AND MILITARY SYSTEMS

**TABLE III**  
**CLASS B**  
**INTEGRATED CIRCUITS**  
(Class C plus burn in screening  
and additional testing.)

| Screening Procedure per MIL-STD-883<br>Method 5004, Class B |   | COMMERCIAL<br>OPERATING RANGE   |  | MILITARY<br>OPERATING RANGE |                             |
|---|---|---------------------------------|--|-----------------------------|-----------------------------|
|   |   | HERMETIC AND<br>MOLDED PACKAGES |  | HERMETIC<br>PACKAGE ONLY    |                             |
|   |   | B1                              | B2   | B3                          | B4                          |
| Screen  | Test Method                                 | Commercial<br>Product           | Commercial<br>Product<br>With 100%<br>Temperature<br>Testing | Military<br>Product         | Jan<br>Qualified<br>Product |
| <b>VISUAL AND MECHANICAL</b>                                |   |                                 |  |                             |                             |
| Internal visual   | 2010, Condition B                           | 100%                            | 100%   | 100%                        | 100%                        |
| High temperature storage                                    | 1008, Condition C, 24 hours                 | 100%                            | 100%   | 100%                        | 100%                        |
| Temperature cycle   | 1010, Condition C                           | 100%                            | 100%   | 100%                        | 100%                        |
| Constant acceleration                                       | 2001  | 100% (1)                        | 100% (1)   | 100%                        | 100%                        |
| Hermeticity, Fine and Gross                                 | 1014  | 100% (1)                        | 100% (1)   | 100%                        | 100%                        |
| <b>BURN IN</b>  |   |                                 |  |                             |                             |
| Interim (pre burn in) electricals                           | Per applicable device specification         | 100%                            | 100%   | 100%                        | 100%                        |
| Burn in   | 1015, 160 hours at 125°C or equivalent.*    | 100%                            | 100%   | 100%                        | 100%                        |
| <b>FINAL ELECTRICAL TESTS</b>                               |   | AMD Data Sheet                  | AMD Data Sheet   | AMD Data Sheet              | 38510 Slash Sheet           |
| Static (dc)   | a) At 25°C, and power supply extremes       | 100%                            | 100%   | 100%                        | 100%                        |
|   | b) At temperature and power supply extremes | (2)                             | 100% (3)   | 100%                        | 100%                        |
| Functional  | a) At 25°C, and power supply extremes       | 100%                            | 100%   | 100%                        | 100%                        |
|   | b) At temperature and power supply extremes | (2)                             | 100% (3)   | 100%                        | 100%                        |
| Switching (ac) or Dynamic                                   | At 25°C, nominal power supply               | (2)                             | (2)  | 100%                        | 100%                        |
| <b>QUALITY CONFORMANCE</b>                                  | 5005, Group A (See Table II)                | Sample                          | Sample   | Sample                      | Sample                      |
| Sample Tests  | Group B                                     | —                               | —  | (4)                         | Sample                      |
|   | Group C                                     | —                               | —  | (4)                         | Sample                      |
|   | Group D                                     | —                               | —  | (4)                         | Sample                      |
| <b>EXTERNAL VISUAL</b>                                      | 2009 (Note 5)                               | 100%                            | 100%   | 100%                        | 100%                        |

Notes: 1. Not applicable to molded packages.

2. All MOS RAMs and many other MOS devices receive a.c. testing and 100% d.c. screening at high temperature and power supply extremes as standard. Other products sampled at Group A (Table III).

3. Tested at high temperature, 100°C, only on commercial range product. Note that this is a full d.c. check of all parameters in addition to the simple "hot-rail" functional sequence performed on most other commercial programs.

4. Available to special order.

5. Without optical aid for commercial devices.

\*Unless otherwise specified on the device data sheet.

## CLASS S FOR AEROSPACE SYSTEMS. (FORMERLY CLASS A)

Advanced Micro Devices offers a Class S program.

This program together with other high reliability screening options, such as SEM and x-ray, is described as Option A in Advanced Micro Devices' Extended Processing Options Document 00-003. Contact your local Advanced Micro Devices' sales office for more information.

**A**

# SCREENING SUMMARY AND ORDERING INFORMATION

## 1. COMMERCIAL PRODUCT

- Screened per MIL-STD-883, Method 5004.
- Electrically tested per AMD Data Sheet.
- Supplied in hermetic and molded packages.
- Quality conformance testing, Method 5005, Group A, performed to levels specified for Class B on both Class C and Class B options.

### Class C (Flow C1)

- Order standard AMD part number.
- Marked same as order number.

Example: Am2901ADC

### Class B (Flow B1)

- Burn in performed in AMD circuit condition.
- Order standard AMD part number, add suffix B (or /883B for 1, 2 and 300 Series Linear devices).
- Marked same as order number.

Example: Am2901ADC-B

## 3. MILITARY PRODUCT

- Screened per MIL-STD-883, Method 5004.
- Electrically tested per AMD Data Sheet.
- Supplied in hermetic package only.
- Quality conformance testing, Method 5005, Group A, performed to levels specified for Class B on both Class B and Class C options.

### Class C (Flow C3)

- Order standard AMD part number.
- Marked same as order number.

Example: Am2901ADM

### Class B (Flow B3)

- Burn in performed in AMD circuit condition.
- AC at 25°C, dc and functional testing at 25°C as well as temperature and power supply extremes performed on 100% of every lot.
- Quality conformance testing, Method 5005, Groups B, C and D available to special order.
- Order standard AMD part number, add suffix B.
- Marked same as order number.

Example: Am2901ADM-B

## 2. COMMERCIAL PRODUCT WITH 100% TEMPERATURE TESTING

- Identical to standard commercial operating range product with the addition of 100% dc and functional testing at 100°C and power supply extremes.

### Class C (Flow C2)

- Order standard AMD part number, add suffix T.
- Marked same as order number.

Example: Am2901ADC-T

### Class B (Flow B2)

- Burn in performed in AMD circuit condition.
- Order standard AMD part number, add suffix TB.
- Marked same as order number.

Example: Am2901ADC-TB

## 4. JAN QUALIFIED PRODUCT

- Screened per MIL-STD-883, Method 5004.
- Electrically tested to JAN detail specification (slash sheet).
- Manufactured in Defense Logistics Agency certified facility.
- Quality conformance testing, Method 5005, Groups A, B, C and D performed as standard and must be completed prior to shipment.
- It is a product for which AMD has gained QPL listing.\*

### Class C (Flow C4)

- Order per military document.
- Marked per military document.

Example: JM38510/44001CQB

### Class B (Flow B4)

- Burn in performed in circuit condition approved for JAN devices.
- Order per military document.
- Marked per military document.

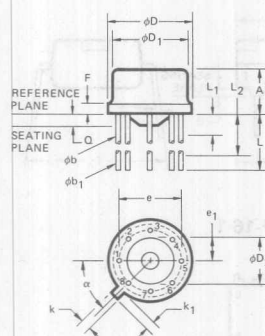
Example: JM38510/44001BRC

\*In certain cases where JAN Qualified product is specified but is not available, Advanced Micro Devices can provide devices to the electrical limits and burn-in criteria of the slash sheet. This class of product has been called JAN Equivalent and marked M38510/ by some manufacturers. This identification is no longer permitted by DESC. Check with your local sales office for availability of specific device types.

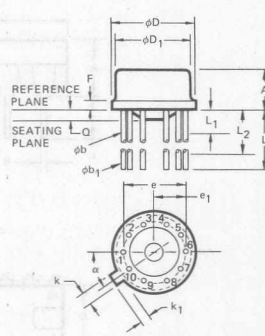
# PACKAGE OUTLINES

## METAL CAN PACKAGES

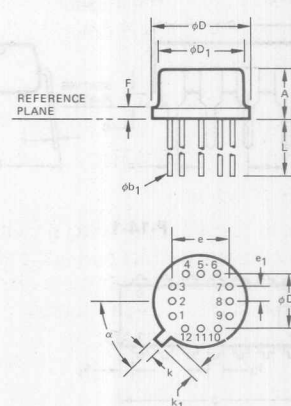
H-8-1



H-10-1



G-12-1



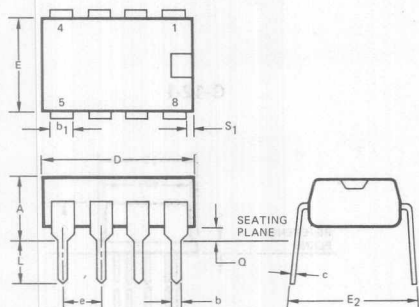
| AMD Pkg.         | H-8-1           |      | H-10-1           |      | G-12-1         |      |
|------------------|-----------------|------|------------------|------|----------------|------|
| Common Name      | TO-99 Metal Can |      | TO-100 Metal Can |      | TO-8 Metal Can |      |
| 38510 Appendix C | A-1             |      | A-2              |      | —              |      |
| Parameters       | Min.            | Max. | Min.             | Max. | Min.           | Max. |
| A                | .165            | .185 | .165             | .185 | .155           | .180 |
| e                | .185            | .215 | .215             | .245 | .390           | .410 |
| e <sub>1</sub>   | .090            | .110 | .105             | .125 | .090           | .110 |
| F                | .013            | .033 | .013             | .033 | .020           | .030 |
| k                | .027            | .034 | .027             | .034 | .024           | .034 |
| k <sub>1</sub>   | .027            | .045 | .027             | .045 | .024           | .038 |
| L                | .500            | .570 | .500             | .610 | .500           | .600 |
| L <sub>1</sub>   |                 | .050 |                  | .050 |                |      |
| L <sub>2</sub>   | .250            |      | .250             |      |                |      |
| $\alpha$         | 45° BSC         |      | 36° BSC          |      | 45°            |      |
| $\phi b$         | .016            | .019 | .016             | .019 |                |      |
| $\phi b_1$       | .016            | .021 | .016             | .021 | .016           | .021 |
| $\phi D$         | .350            | .370 | .350             | .370 | .590           | .610 |
| $\phi D_1$       | .305            | .335 | .305             | .335 | .540           | .560 |
| $\phi D_2$       | .120            | .160 | .120             | .160 | .390           | .410 |
| Q                | .015            | .045 | .015             | .045 |                |      |

Notes: 1. Standard lead finish is bright acid tin plate or gold plate.  
2.  $\phi b$  applies between  $L_1$  and  $L_2$ .  $\phi b_1$  applies between  $L_1$  and 0.500" beyond reference plane.

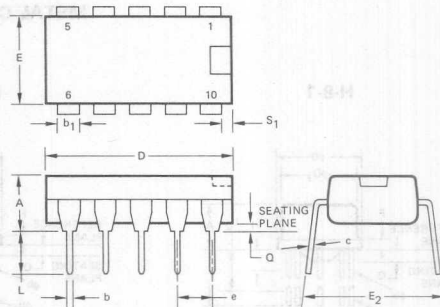
# PACKAGE OUTLINES (Cont.)

## MOLDED DUAL IN-LINE PACKAGES

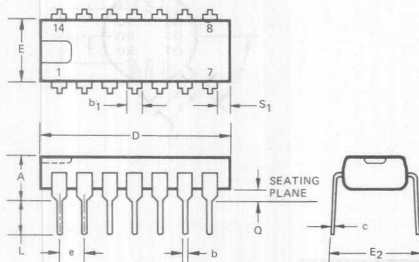
P-8-1



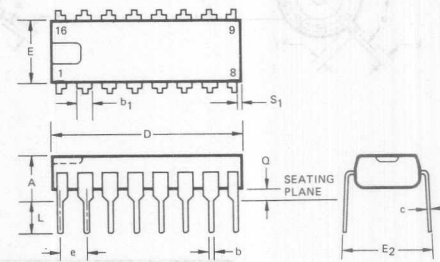
P-10-1



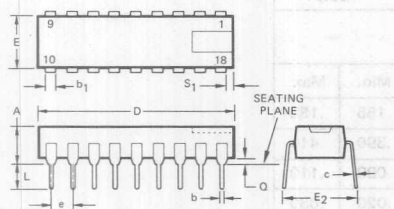
P-14-1



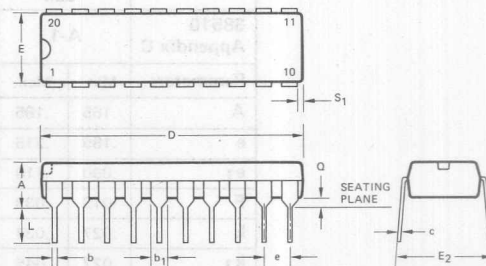
P-16-1



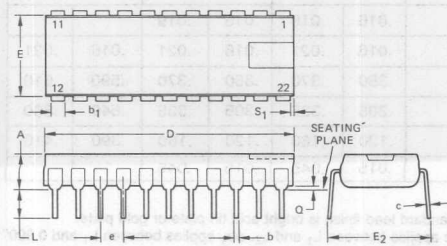
P-18-1



P-20-1



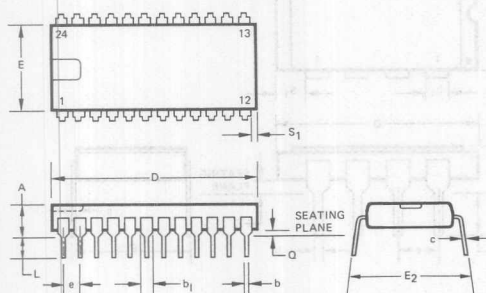
P-22-1



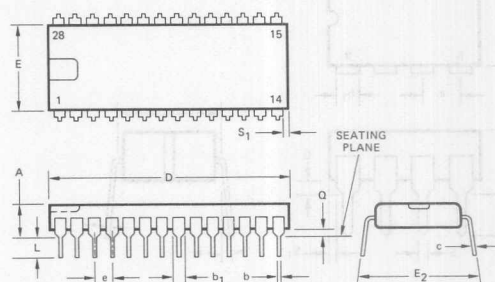
# PACKAGE OUTLINES (Cont.)

## MOLDED DUAL IN-LINE PACKAGES (Cont.)

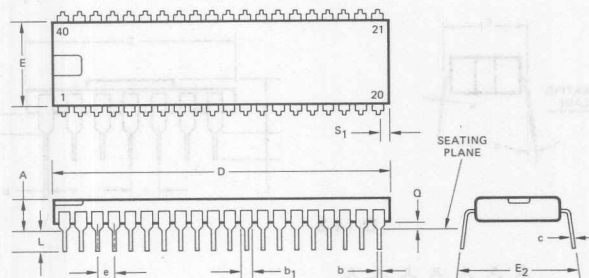
P-24-1



P-28-1



P-40-1



| AMD Pkg.   | P-8-1 |      | P-10-1 |      | P-14-1 |      | P-16-1 |      | P-18-1 |      | P-20-1 |       | P-22-1 |       | P-24-1 |       | P-28-1 |       | P-40-1 |       |
|------------|-------|------|--------|------|--------|------|--------|------|--------|------|--------|-------|--------|-------|--------|-------|--------|-------|--------|-------|
| Parameters | Min.  | Max. | Min.   | Max. | Min.   | Max. | Min.   | Max. | Min.   | Max. | Min.   | Max.  | Min.   | Max.  | Min.   | Max.  | Min.   | Max.  | Min.   | Max.  |
| A          | .150  | .200 | .150   | .200 | .150   | .200 | .150   | .200 | .150   | .200 | .150   | .200  | .150   | .200  | .170   | .215  | .150   | .200  | .150   | .200  |
| b          | .015  | .022 | .015   | .020 | .015   | .020 | .015   | .020 | .015   | .020 | .015   | .020  | .015   | .020  | .015   | .020  | .015   | .020  | .015   | .020  |
| b1         | .055  | .065 | .055   | .065 | .055   | .065 | .055   | .065 | .055   | .065 | .055   | .065  | .055   | .065  | .055   | .065  | .055   | .065  | .055   | .065  |
| c          | .009  | .011 | .009   | .011 | .009   | .011 | .009   | .011 | .009   | .011 | .009   | .011  | .009   | .011  | .009   | .011  | .009   | .011  | .009   | .011  |
| D          | .375  | .395 | .505   | .550 | .745   | .775 | .745   | .775 | .895   | .925 | 1.010  | 1.050 | 1.080  | 1.120 | 1.240  | 1.270 | 1.450  | 1.480 | 2.050  | 2.080 |
| E          | .240  | .260 | .240   | .260 | .240   | .260 | .240   | .260 | .240   | .260 | .250   | .290  | .330   | .370  | .515   | .540  | .530   | .550  | .530   | .550  |
| E2         | .310  | .385 | .310   | .385 | .310   | .385 | .310   | .385 | .310   | .385 | .310   | .385  | .410   | .480  | .585   | .700  | .585   | .700  | .585   | .700  |
| e          | .090  | .110 | .090   | .110 | .090   | .110 | .090   | .110 | .090   | .110 | .090   | .110  | .090   | .110  | .090   | .110  | .090   | .110  | .090   | .110  |
| L          | .125  | .150 | .125   | .150 | .125   | .150 | .125   | .150 | .125   | .150 | .125   | .150  | .125   | .160  | .125   | .160  | .125   | .160  | .125   | .160  |
| Q          | .015  | .060 | .015   | .060 | .015   | .060 | .015   | .060 | .015   | .060 | .015   | .060  | .015   | .060  | .015   | .060  | .015   | .060  | .015   | .060  |
| S1         | .010  | .030 | .040   | .070 | .040   | .065 | .010   | .040 | .030   | .040 | .025   | .055  | .015   | .045  | .035   | .065  | .040   | .070  | .040   | .070  |

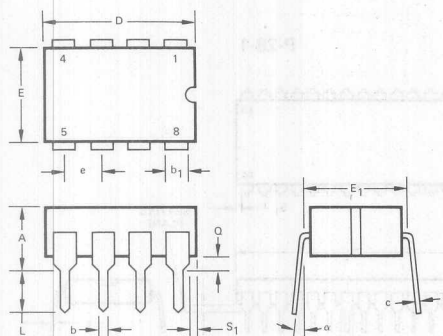
Notes: 1. Standard lead finish is tin plate or solder dip.  
2. Dimension E2 is an outside measurement.



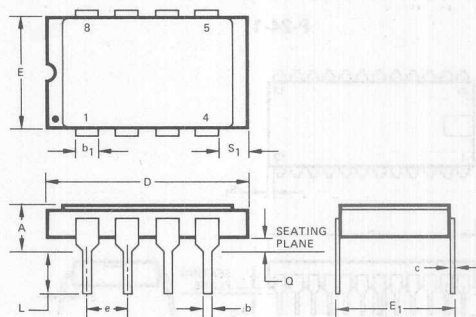
# PACKAGE OUTLINES (Cont.)

## HERMETIC DUAL IN-LINE PACKAGES

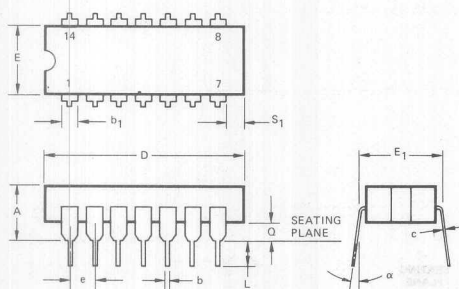
D-8-1



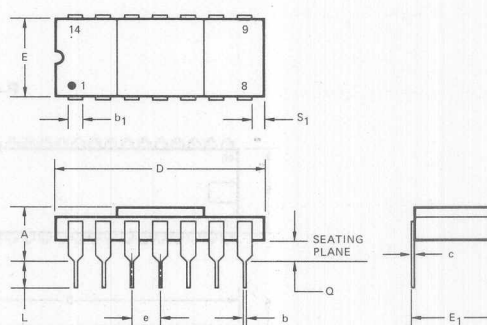
D-8-2



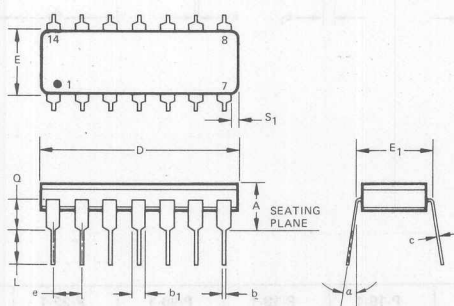
D-14-1



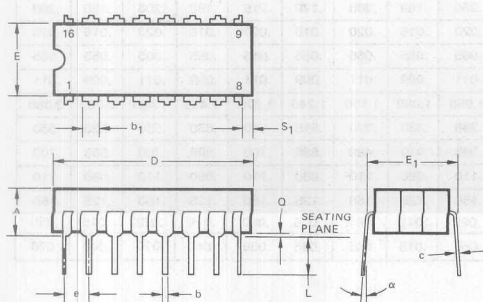
D-14-2



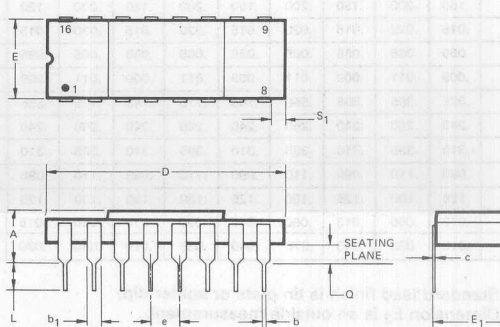
D-14-3



D-16-1



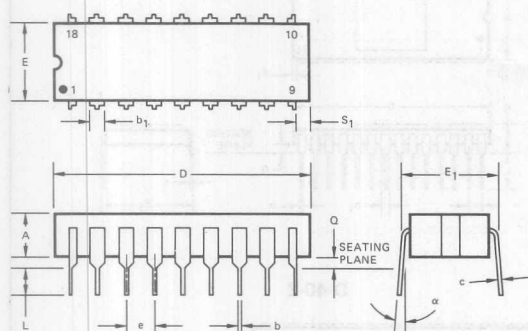
D-16-2



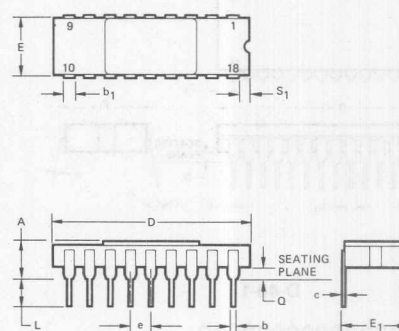
# PACKAGE OUTLINES (Cont.)

## HERMETIC DUAL IN-LINE PACKAGES (Cont.)

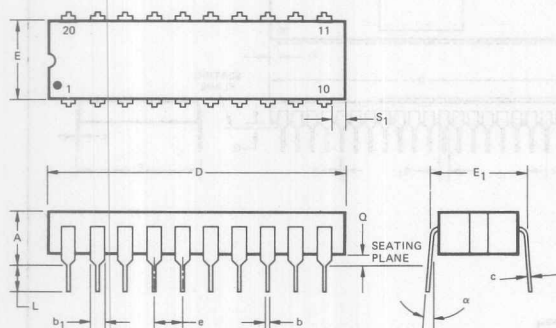
D-18-1



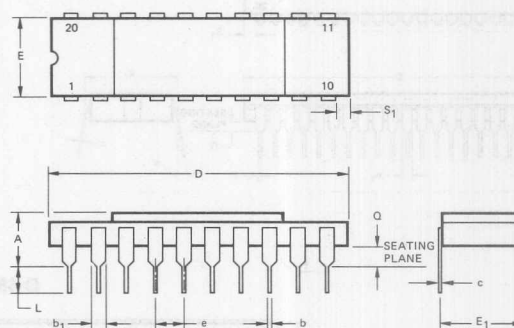
D-18-2



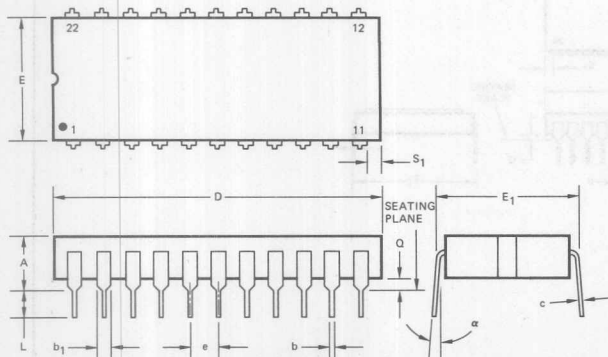
D-20-1



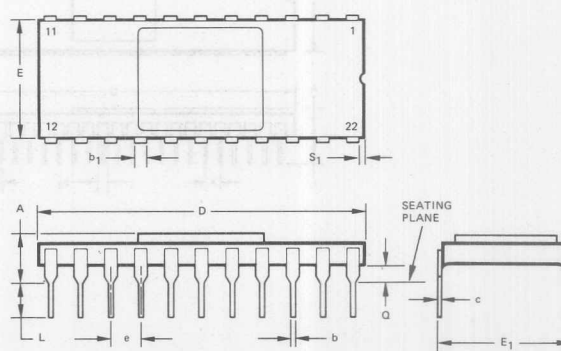
D-20-2



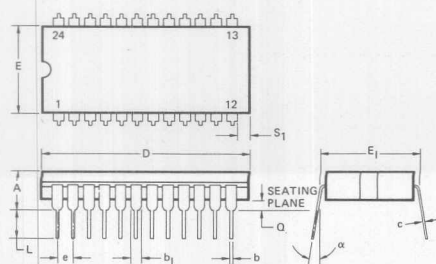
D-22-1



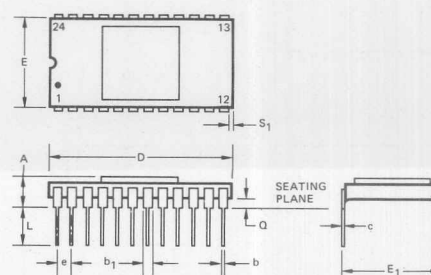
D-22-2



D-24-1 and D-24-4



D-24-2

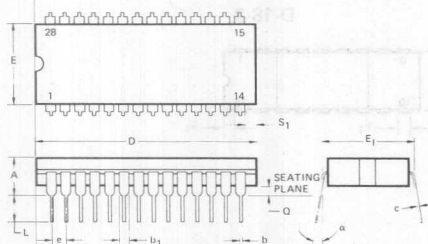


B

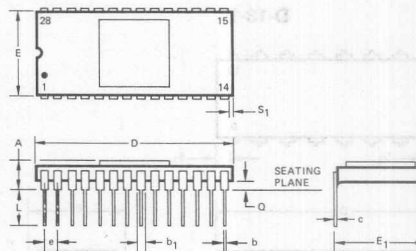
# PACKAGE OUTLINES (Cont.)

## HERMETIC DUAL IN-LINE PACKAGES (Cont.)

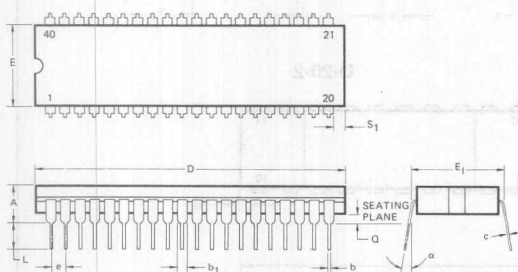
D-28-1



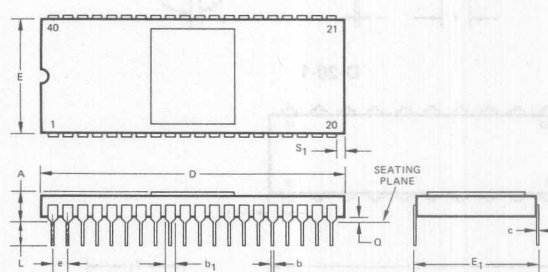
D-28-2



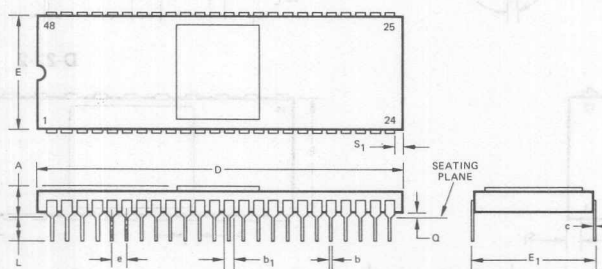
D-40-1



D-40-2



D-48-2



# PACKAGE OUTLINES (Cont.)

## HERMETIC DUAL IN-LINE PACKAGES (Cont.)

| AMD Pkg.             | D-8-1  |      | D-8-2       |      | D-14-1 |      | D-14-2      |      | D-14-3<br>(Note 2) |      | D-16-1 |      | D-16-2      |      |
|----------------------|--------|------|-------------|------|--------|------|-------------|------|--------------------|------|--------|------|-------------|------|
| Common Name          | CERDIP |      | SIDE-BRAZED |      | CERDIP |      | SIDE-BRAZED |      | METAL DIP          |      | CERDIP |      | SIDE-BRAZED |      |
| 38510 Appendix C     | —      |      | —           |      | D-1(1) |      | D-1(3)      |      | D-1(1)             |      | D-2(1) |      | D-2(3)      |      |
| Parameters           | Min.   | Max. | Min.        | Max. | Min.   | Max. | Min.        | Max. | Min.               | Max. | Min.   | Max. | Min.        | Max. |
| A                    | .130   | .200 | .100        | .200 | .130   | .200 | .100        | .200 | .100               | .200 | .130   | .200 | .100        | .200 |
| b                    | .016   | .020 | .015        | .022 | .016   | .020 | .015        | .022 | .015               | .023 | .016   | .020 | .015        | .022 |
| b <sub>1</sub>       | .050   | .070 | .040        | .065 | .050   | .070 | .040        | .065 | .030               | .070 | .050   | .070 | .040        | .065 |
| c                    | .009   | .011 | .008        | .013 | .009   | .011 | .008        | .013 | .008               | .011 | .009   | .011 | .008        | .013 |
| D                    | .370   | .400 | .500        | .540 | .745   | .785 | .690        | .730 | .660               | .785 | .745   | .785 | .780        | .820 |
| E                    | .240   | .285 | .260        | .310 | .240   | .285 | .260        | .310 | .230               | .265 | .240   | .310 | .260        | .310 |
| E <sub>1</sub>       | .300   | .320 | .290        | .320 | .290   | .320 | .290        | .320 | .290               | .310 | .290   | .320 | .290        | .320 |
| e                    | .090   | .110 | .090        | .110 | .090   | .110 | .090        | .110 | .090               | .110 | .090   | .110 | .090        | .110 |
| L                    | .125   | .150 | .125        | .160 | .125   | .150 | .125        | .160 | .100               | .150 | .125   | .150 | .125        | .160 |
| Q                    | .015   | .060 | .020        | .060 | .015   | .060 | .020        | .060 | .020               | .080 | .015   | .060 | .020        | .060 |
| S <sub>1</sub>       | .004   |      | .005        |      | .010   |      | .005        |      | .020               |      | .005   |      | .005        |      |
| α                    | 3°     | 13°  |             |      | 3°     | 13°  |             |      | 3°                 | 13°  | 3°     | 13°  |             |      |
| Standard Lead Finish | b      |      | b or c      |      | b      |      | b or c      |      | c                  |      | b      |      | b or c      |      |

| AMD Pkg.             | D-18-1 |      | D-18-2      |      | D-20-1 |      | D-20-2      |       | D-22-1 |       | D-22-2      |       | D-24-1 |       |
|----------------------|--------|------|-------------|------|--------|------|-------------|-------|--------|-------|-------------|-------|--------|-------|
| Common Name          | CERDIP |      | SIDE-BRAZED |      | CERDIP |      | SIDE-BRAZED |       | CERDIP |       | SIDE-BRAZED |       | CERDIP |       |
| 38510 Appendix C     | —      |      | —           |      | —      |      | —           |       | —      |       | —           |       | D-3(1) |       |
| Parameters           | Min.   | Max. | Min.        | Max. | Min.   | Max. | Min.        | Max.  | Min.   | Max.  | Min.        | Max.  | Min.   | Max.  |
| A                    | .130   | .200 | .100        | .200 | .140   | .220 | .100        | .200  | .140   | .220  | .100        | .200  | .150   | .225  |
| b                    | .016   | .020 | .015        | .022 | .016   | .020 | .015        | .022  | .016   | .020  | .015        | .022  | .016   | .020  |
| b <sub>1</sub>       | .050   | .070 | .040        | .065 | .050   | .070 | .040        | .065  | .045   | .065  | .030        | .060  | .045   | .065  |
| c                    | .009   | .011 | .008        | .013 | .009   | .011 | .008        | .013  | .009   | .011  | .008        | .013  | .009   | .011  |
| D                    | .870   | .920 | .850        | .930 | .935   | .970 | .950        | 1.010 | 1.045  | 1.110 | 1.050       | 1.110 | 1.230  | 1.285 |
| E                    | .280   | .310 | .260        | .310 | .245   | .285 | .260        | .310  | .360   | .405  | .360        | .410  | .510   | .545  |
| E <sub>1</sub>       | .290   | .320 | .290        | .320 | .290   | .320 | .290        | .320  | .390   | .420  | .390        | .420  | .600   | .620  |
| e                    | .090   | .110 | .090        | .110 | .090   | .110 | .090        | .110  | .090   | .110  | .090        | .110  | .090   | .110  |
| L                    | .125   | .150 | .125        | .160 | .125   | .150 | .125        | .160  | .125   | .150  | .125        | .160  | .120   | .150  |
| Q                    | .015   | .060 | .020        | .060 | .015   | .060 | .020        | .060  | .015   | .060  | .020        | .060  | .015   | .060  |
| S <sub>1</sub>       | .005   |      | .005        |      | .005   |      | .005        |       | .005   |       | .005        |       | .010   |       |
| α                    | 3°     | 13°  |             |      | 3°     | 13°  |             |       | 3°     | 13°   |             |       | 3°     | 13°   |
| Standard Lead Finish | b      |      | b or c      |      | b      |      | b or c      |       | b      |       | b or c      |       | b      |       |

B

# PACKAGE OUTLINES (Cont.)

## HERMETIC DUAL IN-LINE PACKAGES (Cont.)

| AMD Pkg.             | D-24-2      |       | D-24-4  |       | D-28-1 |       | D-28-2      |       | D-40-1 |       | D-40-2      |       | D-48-2      |       |
|----------------------|-------------|-------|---------|-------|--------|-------|-------------|-------|--------|-------|-------------|-------|-------------|-------|
| Common Name          | SIDE-BRAZED |       | CERVIEW |       | CERDIP |       | SIDE-BRAZED |       | CERDIP |       | SIDE-BRAZED |       | SIDE-BRAZED |       |
| 38510 Appendix C     | D-3(3)      |       | —       |       | —      |       | —           |       | D-5    |       | —           |       | —           |       |
| Parameters           | Min.        | Max.  | Min.    | Max.  | Min.   | Max.  | Min.        | Max.  | Min.   | Max.  | Min.        | Max.  | Min.        | Max.  |
| A                    | .100        | .200  | .150    | .225  | .150   | .225  | .100        | .200  | .150   | .225  | .100        | .200  | .100        | .200  |
| b                    | .015        | .022  | .016    | .020  | .016   | .020  | .015        | .022  | .016   | .020  | .015        | .022  | .015        | .022  |
| b <sub>1</sub>       | .030        | .060  | .045    | .065  | .045   | .065  | .030        | .060  | .045   | .065  | .030        | .060  | .030        | .060  |
| c                    | .008        | .013  | .009    | .011  | .009   | .011  | .008        | .013  | .009   | .011  | .008        | .013  | .008        | .013  |
| D                    | 1.170       | 1.200 | 1.235   | 1.280 | 1.440  | 1.500 | 1.380       | 1.420 | 2.020  | 2.100 | 1.960       | 2.040 | 2.370       | 2.430 |
| E                    | .550        | .610  | .510    | .550  | .510   | .550  | .560        | .600  | .510   | .550  | .550        | .610  | .570        | .610  |
| E <sub>1</sub>       | .590        | .620  | .600    | .630  | .600   | .630  | .590        | .620  | .600   | .630  | .590        | .620  | .590        | .620  |
| e                    | .090        | .110  | .090    | .110  | .090   | .110  | .090        | .110  | .090   | .110  | .090        | .110  | .090        | .110  |
| L                    | .120        | .160  | .120    | .150  | .120   | .150  | .120        | .160  | .120   | .150  | .120        | .160  | .125        | .160  |
| Q                    | .020        | .060  | .015    | .060  | .015   | .060  | .020        | .060  | .015   | .060  | .020        | .060  | .020        | .060  |
| S <sub>1</sub>       | .005        |       | .010    |       | .005   |       | .005        |       | .005   |       | .005        |       | .005        |       |
| α                    |             |       | 3°      | 13°   | 3°     | 13°   |             |       | 3°     | 13°   |             |       |             |       |
| Standard Lead Finish | b or c      |       |         |       | b      |       | b           |       | b      |       | b or c      |       | b or c      |       |

- Notes: 1. Load finish b is tin plate. Finish c is gold plate.  
2. Used only for LM108/LM108A.  
3. Dimensions E and D allow for off-center lid, meniscus and glass overrun.

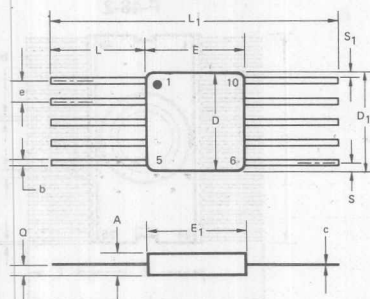
| AMD Pkg.             | D-24-2      |       | D-24-4  |       | D-28-1 |       | D-28-2      |       | D-40-1 |       | D-40-2      |       | D-48-2      |       |
|----------------------|-------------|-------|---------|-------|--------|-------|-------------|-------|--------|-------|-------------|-------|-------------|-------|
| Common Name          | SIDE-BRAZED |       | CERVIEW |       | CERDIP |       | SIDE-BRAZED |       | CERDIP |       | SIDE-BRAZED |       | SIDE-BRAZED |       |
| 38510 Appendix C     | D-3(3)      |       | —       |       | —      |       | —           |       | D-5    |       | —           |       | —           |       |
| Parameters           | Min.        | Max.  | Min.    | Max.  | Min.   | Max.  | Min.        | Max.  | Min.   | Max.  | Min.        | Max.  | Min.        | Max.  |
| A                    | .100        | .200  | .150    | .225  | .150   | .225  | .100        | .200  | .150   | .225  | .100        | .200  | .100        | .200  |
| b                    | .015        | .022  | .016    | .020  | .016   | .020  | .015        | .022  | .016   | .020  | .015        | .022  | .015        | .022  |
| b <sub>1</sub>       | .030        | .060  | .045    | .065  | .045   | .065  | .030        | .060  | .045   | .065  | .030        | .060  | .030        | .060  |
| c                    | .008        | .013  | .009    | .011  | .009   | .011  | .008        | .013  | .009   | .011  | .008        | .013  | .008        | .013  |
| D                    | 1.170       | 1.200 | 1.235   | 1.280 | 1.440  | 1.500 | 1.380       | 1.420 | 2.020  | 2.100 | 1.960       | 2.040 | 2.370       | 2.430 |
| E                    | .550        | .610  | .510    | .550  | .510   | .550  | .560        | .600  | .510   | .550  | .550        | .610  | .570        | .610  |
| E <sub>1</sub>       | .590        | .620  | .600    | .630  | .600   | .630  | .590        | .620  | .600   | .630  | .590        | .620  | .590        | .620  |
| e                    | .090        | .110  | .090    | .110  | .090   | .110  | .090        | .110  | .090   | .110  | .090        | .110  | .090        | .110  |
| L                    | .120        | .160  | .120    | .150  | .120   | .150  | .120        | .160  | .120   | .150  | .120        | .160  | .125        | .160  |
| Q                    | .020        | .060  | .015    | .060  | .015   | .060  | .020        | .060  | .015   | .060  | .020        | .060  | .020        | .060  |
| S <sub>1</sub>       | .005        |       | .010    |       | .005   |       | .005        |       | .005   |       | .005        |       | .005        |       |
| α                    |             |       | 3°      | 13°   | 3°     | 13°   |             |       | 3°     | 13°   |             |       |             |       |
| Standard Lead Finish | b or c      |       |         |       | b      |       | b           |       | b      |       | b or c      |       | b or c      |       |



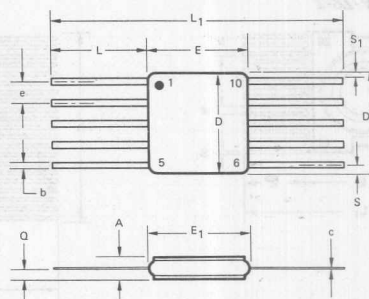
# PACKAGE OUTLINES (Cont.)

## FLAT PACKAGES

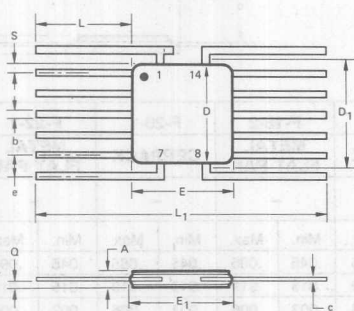
F-10-1



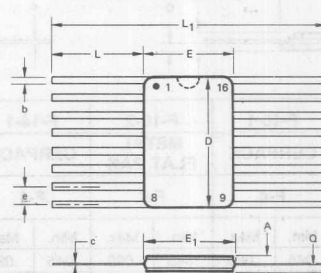
F-10-2



F-14-1 and F-14-2

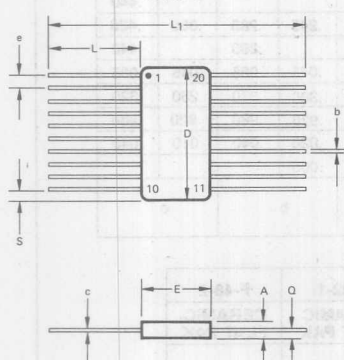


F-16-1 and F-16-2

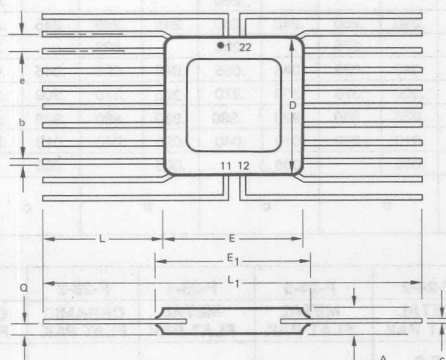


Note: Notch is pin 1 index on cerpack.

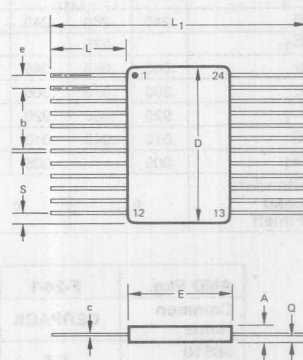
F-20-1



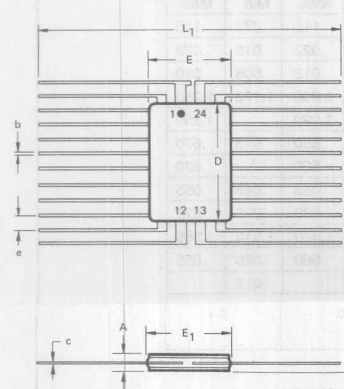
F-22-1



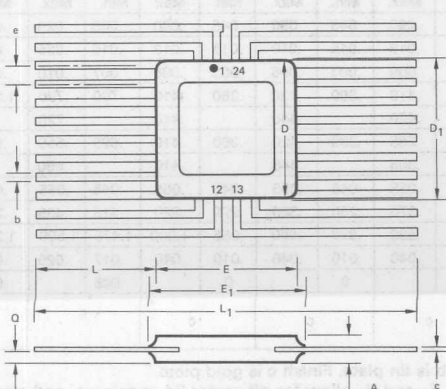
F-24-1



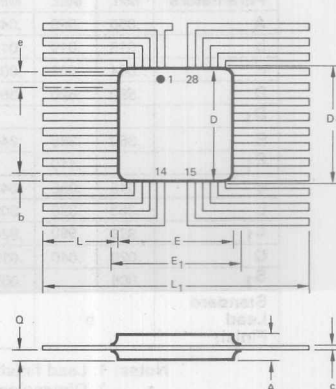
F-24-2



F-24-3



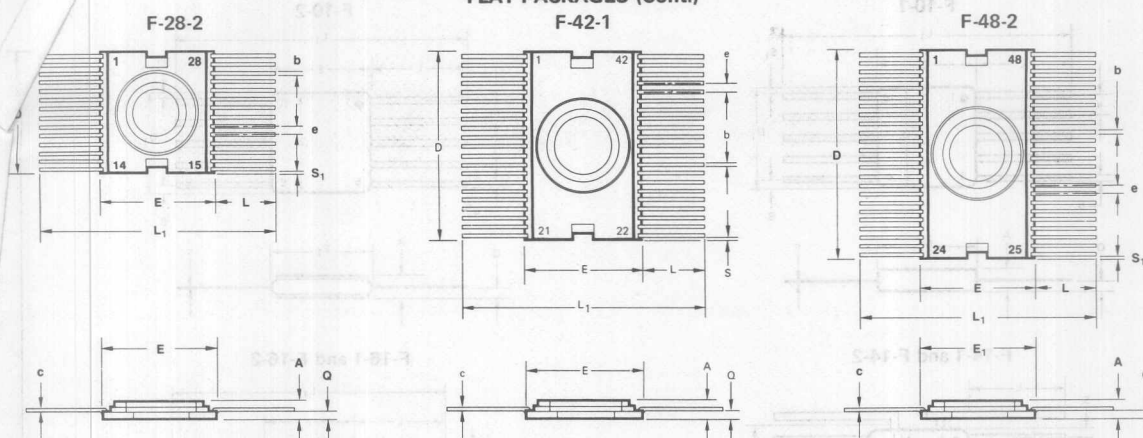
F-28-1



B

# E OUTLINES (Cont.)

## FLAT PACKAGES (Cont.)



| AMD Pkg.<br>Common Name    | F-10-1<br>CERPACK |      | F-10-2<br>METAL<br>FLAT PAK |      | F-14-1<br>CERPACK |      | F-14-2<br>METAL<br>FLAT PAK |      | F-16-1<br>CERPACK |      | F-16-2<br>METAL<br>FLAT PAK |      | F-20-1<br>CERPACK |      | F-22-1<br>METAL<br>FLAT PAK |      |
|----------------------------|-------------------|------|-----------------------------|------|-------------------|------|-----------------------------|------|-------------------|------|-----------------------------|------|-------------------|------|-----------------------------|------|
| 38510<br>Appendix C        | F-4               |      | F-4                         |      | F-1               |      | F-1                         |      | F-5               |      | —                           |      | —                 |      | —                           |      |
| Parameters                 | Min.              | Max. | Min.                        | Max. | Min.              | Max. | Min.                        | Max. | Min.              | Max. | Min.                        | Max. | Min.              | Max. | Min.                        | Max. |
| A                          | .045              | .080 | .045                        | .080 | .045              | .080 | .045                        | .085 | .045              | .085 | .045                        | .085 | .045              | .085 | .045                        | .090 |
| b                          | .015              | .019 | .012                        | .019 | .015              | .019 | .012                        | .019 | .015              | .019 | .015                        | .019 | .015              | .019 | .015                        | .019 |
| c                          | .004              | .006 | .003                        | .006 | .004              | .006 | .003                        | .006 | .004              | .006 | .003                        | .006 | .004              | .006 | .003                        | .006 |
| D                          | .230              | .255 | .235                        | .275 | .230              | .255 | .230                        | .270 | .370              | .425 | .370                        | .400 | .490              | .520 | .380                        | .420 |
| D <sub>1</sub>             |                   |      |                             | .275 |                   |      |                             | .280 |                   |      |                             | .410 |                   |      |                             | .440 |
| E                          | .240              | .260 | .240                        | .260 | .240              | .260 | .240                        | .260 | .245              | .285 | .245                        | .285 | .245              | .285 | .380                        | .420 |
| E <sub>1</sub>             |                   | .275 |                             | .280 |                   | .275 |                             | .280 |                   | .290 |                             | .305 |                   | .290 |                             | .440 |
| e                          | .045              | .055 | .045                        | .055 | .045              | .055 | .045                        | .055 | .045              | .055 | .045                        | .055 | .045              | .055 | .045                        | .055 |
| L                          | .300              | .370 | .300                        | .370 | .300              | .370 | .300                        | .370 | .300              | .370 | .300                        | .370 | .300              | .370 | .250                        | .320 |
| L <sub>1</sub>             | .920              | .980 | .920                        | .980 | .920              | .980 | .920                        | .980 | .920              | .980 | .920                        | .980 | .920              | .980 | .920                        | .980 |
| Q                          | .010              | .040 | .010                        | .040 | .010              | .040 | .010                        | .040 | .020              | .040 | .010                        | .040 | .020              | .040 | .010                        | .040 |
| S <sub>1</sub>             | .005              |      | .005                        |      | .005              |      | .005                        |      | .005              |      | .005                        |      | .005              |      |                             |      |
| Standard<br>Lead<br>Finish | b                 |      | c                           |      | b                 |      | c                           |      | b                 |      | c                           |      | b                 |      | c                           |      |

| AMD Pkg.<br>Common Name    | F-24-1<br>CERPACK |      | F-24-2<br>METAL<br>FLAT PAK |      | F-24-3<br>METAL<br>FLAT PAK |      | F-28-1<br>METAL<br>FLAT PAK |       | F-28-2<br>CERAMIC<br>FLAT PAK |       | F-42-1<br>CERAMIC<br>FLAT PAK |       | F-48-2<br>CERAMIC<br>FLAT PAK |       |
|----------------------------|-------------------|------|-----------------------------|------|-----------------------------|------|-----------------------------|-------|-------------------------------|-------|-------------------------------|-------|-------------------------------|-------|
| 38510<br>Appendix C        | F-6               |      | F-8                         |      | —                           |      | —                           |       | —                             |       | —                             |       | —                             |       |
| Parameters                 | Min.              | Max. | Min.                        | Max. | Min.                        | Max. | Min.                        | Max.  | Min.                          | Max.  | Min.                          | Max.  | Min.                          | Max.  |
| A                          | .050              | .090 | .045                        | .090 | .045                        | .090 | .045                        | .080  | .065                          | .085  | .070                          | .115  | .070                          | .110  |
| b                          | .015              | .019 | .015                        | .019 | .015                        | .019 | .015                        | .019  | .016                          | .025  | .017                          | .023  | .018                          | .022  |
| c                          | .004              | .006 | .003                        | .006 | .003                        | .006 | .003                        | .006  | .007                          | .010  | .006                          | .012  | .006                          | .010  |
| D                          | .580              | .620 | .360                        | .410 | .380                        | .420 | .360                        | .410  | .700                          | .720  | 1.030                         | 1.090 | 1.175                         | 1.250 |
| D <sub>1</sub>             |                   |      | .420                        |      | .440                        |      | .410                        |       | .720                          |       | 1.090                         |       | 1.250                         |       |
| E                          | .360              | .385 | .245                        | .285 | .380                        | .420 | .360                        | .410  | .625                          | .650  | .620                          | .660  | .615                          | .670  |
| E <sub>1</sub>             |                   | .410 |                             | .305 |                             | .440 |                             | .410  |                               | .650  |                               | .660  |                               | .670  |
| e                          | .045              | .055 | .045                        | .055 | .045                        | .055 | .045                        | .055  | .045                          | .055  | .045                          | .055  | .045                          | .055  |
| L                          | .265              | .320 | .300                        | .370 | .250                        | .320 | .270                        | .320  | .415                          | .435  | .320                          | .370  | .320                          | .370  |
| L <sub>1</sub>             | .920              | .980 | .920                        | .980 | .920                        | .980 | .955                        | 1.000 | 1.475                         | 1.500 | 1.300                         | 1.370 | 1.310                         | 1.365 |
| Q                          | .020              | .040 | .010                        | .040 | .010                        | .040 | .010                        | .040  | .017                          | .025  | .020                          | .060  | .020                          | .055  |
| S <sub>1</sub>             | .005              |      | .005                        |      | 0                           |      | 0                           |       | .005                          |       | .005                          |       | .015                          |       |
| Standard<br>Lead<br>Finish | b                 |      | c                           |      | c                           |      | c                           |       | c                             |       | c                             |       | c                             |       |

- Notes: 1. Lead finish b is tin plate. Finish c is gold plate.  
2. Dimensions E<sub>1</sub> and D<sub>1</sub> allow for off-center lid, meniscus, and glass overrun.